REINFORCER SUBSTITUTABILITY: IMPLICATIONS FOR THE ASSESSMENT AND TREATMENT OF STEREOTYPIC SELF-INJURY

By

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By

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The concept of reinforcer substitutability proposes that in any given situation, a continuum of possible interactions among reinforcers can exist. At one end of this continuum, reinforcers are functionally similar and therefore "substitutable," with one reinforcer being readily traded for another. At the other end of the continuum, reinforcers are consumed jointly and are therefore "complementary," with consumption of one reinforcer resulting in an increase in consumption of another reinforcer. Study 1 examined the interaction between substitutable reinforcers with three developmentally disabled individuals who engaged in self-injurious behavior maintained by automatic reinforcement. Two individuals who engaged in hand mouthing, and a third who engaged in arm rubbing, participated. Results of three experiments showed that (a) substitution effects occurred when toys and hand mouthing/arm rubbing were concurrently available, with subjects

showing a strong preference for toy manipulation; (b) attempts to reduce hand mouthing/arm rubbing using the preferred toys as reinforcers in DRO contingencies were unsuccessful for all three subjects; and (c) all three subjects' preferences for hand mouthing/arm rubbing or toy play systematically changed when reinforcer "cost" was varied. Study 2 examined the interaction between complementary reinforcers. Two developmentally disabled men who engaged in hand mouthing participated. Results of three experiments showed that (a) both subjects' hand mouthing increased when food was consumed; (b) varying the amount of food had no effect on hand mouthing for either subject; and (c) food reinforcers were ineffective in either decreasing hand mouthing (one subject) or increasing appropriate behavior (the other subject). The results of the two studies illustrate the importance of examining interactions among concurrently available reinforcers when conducting reinforcer assessments.

INTRODUCTION

It has long been recognized that behavior is affected in numerous and sometimes complex ways by stimuli in the environment. For example, the probability of responding is affected not only by events that precede and follow a particular behavior, but also by the presence of alternative (concurrent) response options. In applied settings, where stimuli are often not amenable to direct control, the analysis of environment-behavior interactions is particularly troublesome when behavior produces its own consequences. The source of reinforcement for such behavior is often unclear and, even if the stimulation can be identified, it is usually difficult or impossible to separate the behavior from its product. Therefore, most reinforcement-based interventions aimed at reducing automatically-reinforced aberrant behavior have necessarily involved choices between concurrently available reinforcers.

A considerable amount of basic research has examined the interaction between concurrently available reinforcers. For example, the matching law (Herrnstein, 1961, 1970) was an initial attempt to account for the relativistic nature of reinforcement: The effect of a given reinforcer is dependent upon the availability of other reinforcers within a particular situation. Hernnstein's matching law was quite accurate in predicting outcomes when concurrent reinforcers were qualitatively similar (and usually identical), but less so when choices were between qualitatively different reinforcers (Baum, 1974). Subsequent research has expanded our understanding of the nature of reinforcement by incorporating economic principles, specifically that of reinforcer substitutability, into behavioral analyses when reinforcers are not qualitatively identical (Rachlin, Green, Kagel, & Battalio, 1976). Given the findings of behavioral economic research, an examination of the parameters

affecting the relationship between automatically-reinforced behavior and other environmental stimuli seems long overdue. The purpose of the two studies that follow is to examine both substitutable and complementary relationships between stereotypic self-injury and environmental stimuli. In Study One, three experiments were conducted. Experiment One was a simple demonstration of the substitutability of toy play for hand mouthing (two subjects) and arm rubbing (one subject), Experiment Two examined the efficacy of DRO using the toys as reinforcers, and Experiment Three examined the effect of altering "response effort" for the preferred reinforcer (toy play) on the amount of hand mouthing/arm rubbing and toy play. Study Two examined complementary relationships between hand mouthing and food consumption. Experiment One demonstrated a complementary relationship between hand mouthing and food consumption with two subjects, Experiment Two examined the effect of amount of food on time spent hand mouthing, and Experiment Three examined the efficacy of food as a reinforcer in a DRO contingency (one subject) and on a free operant task (one subject).

Behavior Disorders Maintained by Automatic Reinforcement

Although considerable research has shown that many behavior problems are maintained by social reinforcement such as attention from caregivers (Day, Rea, Schussler, Larsen, & Johnson, 1988), or escape from task instructions (Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990), it has also often been found that some behavior problems persist in the absence of social consequences (Iwata et al., 1994). Persons with severe developmental disabilities have frequently been found to engage in behaviors that appear to be maintained by directly (automatically) produced sensory consequences. Examples of such behavior include repetitive and rhythmic "stereotypic" movements such as body rocking, object manipulation, and complex hand and finger movements (Repp & Karsh, 1990), and some cases of self-injury such as hand mouthing (Rast & Jack, 1992),

trichotillomania (Rothbaum, 1992), aerophagia (Barrett, McGonigle, Ackles, & Bruhart, 1987), and pica (Danford & Huber, 1982).

Functional analyses designed to identify variables affecting the occurrence of behavior disorders (Carr & Durand, 1985; Iwata, Dorsey,Slifer, Bauman, & Richman, 1982; Mace & Lalli, 1991; Wacker, et al., 1990) have been demonstrated as useful tools for identifying social functions for problem behavior and in the subsequent development of effective treatments. For example, successful interventions based on results of functional analyses have been demonstrated for self-injury maintained by escape from instructions (Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990; Steege, Wacker, Berg, Cigrand, & Cooper, 1989), and by contingent attention (Day et al., 1988; Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993). In addition, there is evidence that identification of the maintaining variables improves the efficacy of treatment (Iwata, Pace, Kalsher, Cowdery, & Cataldo, 1990; Repp & Karsh, 1990). The utility and generality of functional analyses have also been supported by numerous studies across response topographies, subject populations, and settings (e.g., see Iwata, Vollmer, & Zarcone, 1990; and Mace, Lalli, & Pinter-Lalli, 1991, for reviews).

As with the assessment of socially-mediated behavior, identification of sources of control for nonsocially-mediated behavior could lead to more effective treatment interventions. But unlike socially-mediated behavior, for which the maintaining variables can be identified among observable events, many automatically-reinforced behaviors have their sources of control from unobservable events that are difficult to identify and manipulate. Typically, researchers and therapists would assume automatic reinforcement as the maintaining variable based on a functional analysis when exhaustive assessment manipulations produced undifferentiated results, or if the behavior persisted in an alone condition (Shore & Iwata, in press). Therefore, automatic reinforcement has been assumed to be the maintaining variable based on a process of elimination of possible social

functions, rather than on identification of a specific source of control. For example, Iwata, et al. (1994) recently presented results of functional analyses of SIB obtained for 152 subjects over an 11-year period. Interestingly, automatic reinforcement was identified as the maintaining variable (through a process of elimination) for 25.7% (39) of the subjects.

Behavioral Interventions for Stereotypic Self-Injury

Based on the assumption that some cases of self-injury or stereotypy are maintained by their sensory consequences, one treatment strategy known as sensory extinction (Rincover, 1978) has been to attenuate or eliminate the sensory consequences of the behavior. For example, Rincover and Devany (1982) used a padded helmet for one boy who banged his head, covered the floor and walls with padding for another boy who head banged, and placed rubber gloves on a girl who scratched her face. Results showed decreases in self-injury for all three subjects. Although this type of intervention has often been shown effective in reducing stereotypic and self-injurious behavior, the underlying process involved may not be extinction (Mazaleski, Iwata, Rodgers, Vollmer, & Zarcone, 1994). For example, does a helmet merely alter the sensory consequences of head hitting, making it less reinforcing (extinction), or does it increase stimulation to the hand of an individual who strikes the helmet (punishment)? Thus, it is unclear if the actual source of stimulation has been identified and masked or if punishment is the behavioral process involved in behavioral reduction.

There are several drawbacks in the use of sensory extinction. Assuming that the procedure does represent a form of extinction, identification of the behavior's maintaining reinforcers is required. However, many behaviors produce multiple modes of stimulation (e.g.,visual, tactile, auditory). For example, hand mouthing produces tactile and gustatorial stimulation, and object twirling produces tactile, auditory, and visual stimulation, any or all of which could be the maintaining reinforcer. Another potential problem with sensory extinction is that the procedure may be impractical (e.g., eliminating

visual stimulation) unless used on a response-contingent basis or intermittently. Finally, extinction may produce an initial burst in responding and/or other emotional behavior that may preclude its use (Luiselli, 1981).

Given that it may be difficult or impossible to use sensory extinction in some cases, many researchers have focused on reinforcement-based alternatives. Examples include continuous access to alternative reinforcers such as toys (Berkson & Mason, 1965; Davenport & Berkson, 1963; Favell, McGimsey, & Schell, 1982), differential reinforcement of alternative behavior or DRA (Lockwood & Bourland, 1982; Mulick, Hoyt, Rojahn, & Schroeder, 1978), and differential reinforcement of other behavior or DRO (Cowdery, Iwata, & Pace, 1990; Luiselli & Krause, 1981, Repp, Deitz, & Deitz, 1976).

Many studies have found that the availability of certain toys decreased the occurrence of stereotypic behavior. For example, Favell et al. (1982) provided alternative sensory activities to six profoundly retarded subjects who displayed self-injury. In all cases, when these activities were available, eye poking, hand mouthing, and pica were substantially reduced. Selection of the items was based on their similarity to the presumed sensory consequences produced by the target behavior (e.g., brightly colored beads and mirrors for the subjects who eye poked, large rubber balls and popcorn for the subjects who engaged in pica). Thus, it was shown that, in some cases, environmental stimuli could substitute for the automatically-produced reinforcers.

Another strategy for increasing the effectiveness of interventions that provide access to items that substitute for aberrant behavior has been to use differential reinforcement of alternative behavior (Favell et al., 1982; Lockwood & Bourland, 1982; Mulick et al., 1978). For example, Favell et al. used social reinforcement to increase more appropriate toy play (e.g., toy holding versus toy mouthing) and further decrease hand mouthing for three subjects, and used popcorn contingent on appropriate toy usage to decrease toy

chewing and pica for two other subjects. Lockwood and Bourland (1982) showed that although toys affixed to the wheelchair of a developmentally disabled subject reduced SIB by approximately 50%, the addition of differential reinforcement (praise and brief physical contact) for sustained toy use and the absence of finger biting was necessary to achieve clinically acceptable effects. Similarly, Mulick et al. (1978) decreased finger picking and nail biting by differentially reinforcing independent toy play with social and edible reinforcers.

Another approach, differential reinforcement of other behavior (DRO), involves the delivery of reinforcement at the end of a predefined interval provided that the aberrant behavior has not occurred during that time. Cowdery et al. (1990), for example, showed that access to video games contingent on the nonoccurrence of self-scratching was an effective intervention to eliminate self-injury. Repp et al. (1976) reduced the hairtwirling, handbiting, and thumbsucking behavior of three developmentally delayed children in a classroom setting by delivering praise and edible reinforcement in a DRO contingency. Other studies have also shown DRO as an effective intervention for the treatment of stereotypic behavior (Luiselli & Krause, 1981; Repp, Deitz, & Speir, 1974).

Interestingly, interventions that do not include an extinction component (e.g., access to substitutable items as described above, or many cases of DRA or DRO) necessarily produce conditions of choice between concurrently available reinforcers because of the continued availability of the inappropriate behavior (and its resulting consequences) and the arbitrary reinforcer delivered in the intervention. The parameters that affect choice between concurrently available reinforcers have been studied extensively by basic researchers and their findings have important implications for the assessment and treatment of automatically-reinforced problem behavior.

The Matching Law and Reinforcer Substitutability

Herrnstein's matching law (1961, 1970) made explicit the relativistic nature of reinforcement. The matching law predicted that the probability of a given response is influenced not only by the reinforcers contingent upon it, but also by other reinforcers contingent on other responses within the particular situation. The matching law stated that the ratio of responses emitted for two reinforcers would be equal to the ratio of the reinforcement obtained for those responses. A generalized version of the matching law was proposed by Baum (1974), with additional parameters (sensitivity and bias) added to account for cases in which deviations from matching occurred. A considerable amount of basic research has examined the accuracy of the matching law in predicting relative allocation of responding (see de Villiers, 1977, for a review). Most of this research, however, has focused on reinforcers that differ in their frequency, amount, delay, or probability, all of which are quantitative dimensions. For example, choice has typically been examined in procedures with pigeons (or some other nonhuman animal) choosing between identical food reinforcers that differ along one or more of these dimensions. Much less research, however, has been conducted to examine the interactions between qualitatively different reinforcers (Green & Freed, 1994). In its ideal form, the matching law's assumes that reinforcers are perfectly substitutable, yet evidence from basic research shows that under and overmatching occur frequently (Baum, 1979).

The concept of reinforcer substitutability is based on economic theory and was proposed as a possible extension to the generalized matching law (see Green & Freed, 1994, for a review). This theory describes a continuum of interactions between concurrently available reinforcers. At one end of this continuum are complementary reinforcers for which increased consumption of one alternative would result in an increase in consumption of its complement. For example, increased consumption of salty food could result in increased consumption of water. At the other extreme of the continuum are

substitutable reinforcers, for which an increase in consumption of one alternative would result in a decrease in consumption of its substitute. For example, a pencil may be readily traded for a pen when writing. In the middle of the continuum, reinforcers are independent, with consumption of one having no effect on consumption of another. Substitutes and complements, however, are not fixed points along a continuum. For example, although one may readily trade a pencil for a pen when jotting down a quick note, that same person may seek out a pencil instead of a pen when doing a crossword puzzle. Therefore, substitutability and complementarity are not static properties of single reinforcers, but descriptions of the relationship between reinforcers in a given context.

A considerable amount of research over the past decade has been conducted to examine the substitutability of qualitatively different reinforcers. That is, results of these studies show that substitution effects can occur independent of initial preference. Increasing the price of a preferred reinforcer through changes in rate, magnitude, or delay to reinforcement has been shown to eliminate preference for that reinforcer over a substitutable one (Rachlin et al., 1976). For example, in a basic demonstration of substitutability (Kagel et al., 1975), rats responded for either root beer or Tom Collins mix on concurrent fixed ratio (FR) schedules of reinforcement. Each reinforcer was associated with a different response lever and FR requirement. The rats lived in the experimental chamber and were limited to a fixed number of lever presses in a given 24-hr period. In economic terms, the pairs of reinforcers represented different "commodities", the FR requirement represented the "price" of each good, and the total number of lever presses allotted represented the rats' "income". By altering the schedules for each reinforcer, the "price" for each reinforcer could be varied. The results showed that both rats had a strong preference for root beer when the "price" (FR requirement) and "income" (total number of lever presses allotted) were equal. This relationship was then altered by making "income-compensated price changes." This was accomplished by reducing the FR schedule requirement (price) for Tom Collins by half and doubling the FR requirement (price) for

root beer, while adjusting the allotted number of lever presses (income) to obtain the same combination of root beer and Tom Collins as was obtained in the first condition. Results of this manipulation showed much more consumption of the now "cheaper" Tom Collins than the now more "expensive" root beer. Thus, altering the price of the concurrently available reinforcers eliminated the preference that had been shown when prices were equal. Studies such as this show that the context in which a putative reinforcer is used can alter its reinforcing efficacy.

In a more recent case study on reinforcer substitutability in human subjects, Tustin (1994) examined relative preference for reinforcers shown by subjects with developmental disabilities under constant and several different fixed-ratio schedule requirements. For the first subject, two series of schedules were presented singly. In the first series, complex sensory stimuli were presented in a series of FR schedules (e.g., FR 1, FR 2, FR 5, FR 10, FR 20). The second series was identical to the first series of FR schedules, but with attention as the reinforcer. Results showed that, as the FR schedule requirements increased, the subject increased responding more for the complex sensory reinforcer than for the attention reinforcer. This study demonstrated changes in relative preference as FR schedule requirements increased. In the second case study, another subject was exposed to two series of concurrent fixed-ratio schedules. In the first series, the subject responded for a choice between visual reinforcers consistently delivered on an FR 5 schedule, and auditory stimuli delivered in several different FR schedules (the same series described in the first study). Results showed an initially greater number of reinforcers were earned for the auditory stimuli than for the visual stimuli when response requirements for visual stimuli were lower than for auditory stimuli. This preference, however, was eliminated when the schedule requirement for auditory stimuli became greater than that for the constant requirement for visual stimuli. Thus, a substitutable relationship was demonstrated between the visual and auditory stimuli. The third case study showed changes in

preference as a function of schedule requirements. The subject was exposed to one series of concurrent schedules, with choices between constant color stimuli and complex sensory stimuli, both delivered on the same FR schedule. The results showed that in the FR 1 schedule requirement, the constant stimuli were preferred over the complex stimuli. This preference, however, switched as schedule requirements were increased, with increased responding for the complex stimuli and decreased responding for the constant stimuli.

In light of these and other similar basic research studies demonstrating the contextual nature of reinforcement, further analysis of the variables affecting stimulus preference in applied settings seems warranted.

Reinforcer Substitutability and Applied Behavior Analysis

Numerous applied studies have been conducted in recent years assessing stimulus preference. These studies have demonstrated the effectiveness of assessing preference for stimuli prior to using them as reinforcers in teaching adaptive skills (Pace, Ivancic, Edwards, Iwata, & Page, 1985) or in reducing problem behavior (Steege et al., 1989). Basic research studies examining choice between qualitatively different reinforcers, however, suggest that stimulus preference changes with changing context. The variables affecting choice in applied settings and the extent to which assessing reinforcing efficacy in one context is predictive of reinforcer efficacy in another context are clearly in need of further investigation. Indeed, Green and Freed (1994), in their review of studies of substitutability, emphasized that consideration of substitutability is necessary for an adequate understanding of the interactions among reinforcers and their influence on behavior. The study of reinforcer interactions, they suggested, is particularly relevant to applied behavior analysts. In spite of the importance of such research, however, the concept has received little attention in applied behavioral research.

Although not interpreted in terms of reinforcer substitutability, many applied studies have shown substitution effects between environmental stimuli and stereotypic or self-injurious behavior. For example, Favell et al. (1982) effectively decreased developmentally disabled subjects' hand mouthing, pica, and eye poking by providing access to toys, popcorn, and visual toys, respectively. Hence, by matching the presumed source of sensory stimulation produced by the self-injurious behavior to that produced by toy play, they were able to replace the more severe form of self-stimulation with a more benign topography. Favell et al. suggested that these stimuli were "substitutes" for the inappropriate behavior. Other studies have also shown substitutability between toys and stereotypic or self-injurious behavior (Bailey & Meyerson, 1970; Rincover, 1978). Davenport and Berkson (1963), however, showed that this reciprocal relationship varied according to which toys were used. Therefore, this intervention may be effective only to the extent that alternative sensory activities are preferred over the self-stimulatory behavior. Although these simple demonstrations of substitution effects have been reported, the parameters affecting these relationships have not been explored in any systematic manner.

Other applied research has shown that some behaviors tend to directly covary, with engagement in one behavior resulting in engagement in another behavior. For example, Knight and McKenzie (1974) examined the effects of time out from bedtime stories on the thumbsucking behavior of three small children. All three girls were reported to suck their thumbs most often at bed time, when being read to, and when holding a favorite blanket. Thus, thumbsucking can be viewed as a complementary reinforcer to hearing bed time stories and/or holding onto a blanket. Following a baseline in which the mothers read bed time stories without contingencies for thumbsucking, the mother's stopped reading whenever the child started to thumbsuck and only resumed when the child did not thumb suck. Although the authors interpreted this as time out, another interpretation is possible. The time out contingency may have merely reduced consumption of one reinforcer

(thumbsucking) by restricting access to its complement (bed time stories). Other studies suggesting that self-stimulatory behavior may have a complementary relationship with other reinforcers can be found in research examining situational effects on rates of stereotypy. For example, Kaufman and Levitt (1967) found that body rocking displayed by developmentally delayed subjects increased steadily prior to lunch and at times when institutional staff changed shifts. For these subjects, stereotypic behavior may have had a complementary relationship to eating meals and/or staff attention. Complementary relationships such as these, and the parameters affecting those relationships, clearly warrant further examination.

In light of basic research examining the interaction between concurrently available qualitatively different reinforcers, the interaction between automatically-reinforced problem behavior and other environmental stimuli should be explored. Study One examined substitutable relationships between stereotypic self-injury and preferred play items, and Study Two examined the complementary relationship between hand mouthing and food consumption. The experiments for both studies explored the contextual nature of these types of interactions.

GENERAL METHOD

Subject Descriptions

Five individuals with developmental disabilities participated in the two studies. All lived in a public residential facility, and all had been diagnosed with severe/profound mental retardation. The subjects were referred to a specialized program for the assessment and treatment of their SIB. Three subjects, Caryl, Merry, and Randy, participated in Study One. Two subjects, Chuck and Matt, participated in Study Two.

Caryl was a 30-year-old woman whose SIB consisted of hand mouthing that resulted in tissue damage. She was non-ambulatory, displayed no expressive language, and did not appear to respond to directions from caregivers. Merry was a 34-year-old woman whose SIB also consisted of hand mouthing that resulted in substantial tissue damage. She was non-ambulatory, displayed no expressive language, and did not appear to respond to directions from caregivers. Randy was a 33-year-old man whose SIB consisted of high rates of arm rubbing against a chair, table, or other stationary object. His arm rubbing produced only mild skin abrasions, but it interfered considerably with other activities. Randy walked with an unsteady gate and did not display any expressive language, but he did respond to a few simple requests. Chuck was a 45-year-old man whose SIB consisted of head hitting and hand biting. Following assessment and successful treatment for these behaviors, staff reported that Chuck also engaged in hand mouthing when eating certain foods. Chuck was ambulatory and did not display any expressive language, but did respond to simple requests. Matt was a 30-year-old male whose SIB consisted of hand mouthing that resulted in tissue damage. He was non-

ambulatory, had no expressive language, and did not appear to respond to directions from caregivers.

Setting

All of the experiments for both studies were conducted at a day program for the assessment and treatment of SIB, located on the grounds of the subjects' residence. Sessions were conducted by graduate students, with the location of the sessions always the same within each condition. Therapy rooms contained chairs, tables, and other furnishings, as well as materials that varied according to the conditions of the experiments. Sessions lasted for 15 min unless otherwise noted. Between one and three sessions were conducted each day, and sessions were typically conducted four or five days per week.

Functional Analyses

Functional analysis assessments as described by Iwata et al. (1982) were conducted for all five subjects. Results for Caryl, Merry, and Matt showed that hand mouthing occurred across all conditions with the highest percentage of intervals in the alone condition, suggesting that SIB was automatically reinforced. Randy's functional analysis showed that his arm rubbing occurred at high rates across all conditions, also suggesting his SIB was automatically reinforced. Although no hand mouthing occurred during Chuck's functional analysis for SIB, it was observed that when snacks were delivered, he engaged in high rates of hand mouthing.

Stimulus Preference Assessments

Probe sessions were conducted for Caryl, Merry, and Randy to determine toy preferences. Sessions were 10 min in length and consisted of continuous access to a toy. Toys were selected for each subject based on their ability to compete with hand mouthing

(e.g., the toy that resulted in the lowest rate of hand mouthing/arm rubbing). Two large plastic rings were selected for Caryl, a small plastic tube for Merry, and a vibrator for Randy.

Probe sessions were conducted for Chuck and Matt to determine food preferences. Sessions were 15 min in length. For Chuck, different food items were placed on a paper plate in front of him at the start of the session. Matt could not feed himself; therefore, different food items were delivered on a spoon placed at his lips approximately every 10 s. For both subjects, observers recorded occurrences of eating and hand mouthing, and the food that was associated with the highest amount of hand mouthing was selected for inclusion in the study. Kit Kat cookies was selected for Chuck and pudding was selected for Matt.

Response Measurement and Reliability

The dependent variables for the experiments were operationally defined as follows: hand mouthing (Caryl, Merry, Chuck, and Matt)--insertion of the hand or fingers past the plane of the upper and lower lips, or protrusion of the tongue out of the mouth onto the hand or fingers; arm rubbing (Randy)--scraping the arm against the surface of a stationary object; toy play (Caryl, Merry, and Randy)--holding a toy in hand; eating (Chuck and Matt)--food entering the mouth or visible chewing motions of the mouth; blocks in bucket (Chuck)--blocks putting a block into a bucket. Therapist behavior was also scored and defined as follows: toy delivery (Caryl, Merry, and Randy)-- therapist hands the toy to the subject; feeding (Chuck and Matt)-- therapist delivers the food item to the subject; prompts (Chuck)-- therapist places a block in the bucket.

Subject and therapist behaviors were recorded on a hand-held computer (Assistant, Model AST 102) during continuous 10-s intervals. Because the duration of hand mouthing, toy play, and eating varied considerably, a partial-interval scoring procedure

was used, in which observers marked the occurrence of the behavior if it was observed at all during a 10-s interval. Data were converted to the percentage of intervals during which responding occurred. Arm raising was scored as responses per minute by dividing the number of arm raises by the number of minutes in the session. Blocks in bucket, prompts, and feeding were scored as number per session.

A second observer simultaneously but independently recorded data during at least 19% of the sessions in each condition (range across subjects, 19.4% to 48%). Interobserver agreement scores were calculated by first dividing session time into consecutive 10-s intervals. The smaller number of responses was divided by the larger number of responses recorded during each interval, and those values were averaged across the session. Interobserver agreement data were collected for SIB, toy play, and eating. Table One shows the percentage of sessions with interobserver reliability and mean percentage agreement scores obtained for all subjects during each of the experimental conditions.

Table 1

Percentage of Sessions with Interobserver Reliability and Mean Percentage Agreement Scores for Self-Injury, Toy Play, and Eating, during each Experiment of Study One and Study Two

	Percentage of Sessions		
Name	Experiment One	Experiment Two	Experiment Three
Study One			
Caryl	19.4	25	38.5
Merry	32.1	28.8	31.3
Randy	48	25	30.8
Study Two			
Chuck	47.4	32.6	37.5
Matt	37.5	25	27.5

	Mean Percentage Agreement					
Name	Experiment One		Experiment Two		Experiment Three	
	SIB	Toy Play/Eat	SIB	Toy Play/Eat	SIB	Toy Play/Eat
Study One						
Caryl	97.3	96.9	95.5	97.4	94.3	92.8
Merry	96.5	89.7	93.5	93.8	98.1	93.6
Randy	94	96.5	91.6	97.9	93.5	96.7
Study Two						
Chuck	99.8	98.2	93.4	97.8	94.2	94.3
Matt	97.1	99.1	95.9	99.1	97.9	98.4

STUDY ONE

For three of the subjects previously described, Caryl, Merry, and Randy, toys were found during probe sessions that appeared to reduce drastically the occurrence of stereotypic self-injury; that is, were substitutable for hand mouthing. The purpose of Study One was to explore the relationship between toy play and hand mouthing or arm rubbing. Three experiments were conducted: (a) a basic demonstration of the relationship between toy play and hand mouthing; (b) an examination of the effectiveness of the toys as reinforcers in DRO procedures to reduce hand mouthing; and (c) a parametric analysis of the effects of response effort on the occurrence of hand mouthing.

Experiment One

Method

In Experiment One, the relationship between toy play and hand mouthing was examined when both reinforcers were continuously available. The conditions were presented to each subject in a reversal (ABAB) experimental design.

Alone. The subject was alone in the room (with the exception of the observer), with no toys or other materials available. No interactions occurred between the observer and subjects. This condition was identical to the alone condition of the functional analysis.

Toys available. These sessions were identical to baseline sessions, with the exception that toys were given to the subjects at the start of each session. For Caryl, two plastic rings were placed on a tray attached to her wheelchair. For Merry, the plastic tube

was placed in her hand at the start of the session. For Randy, a vibrator was given to him at the start of each session.

Results and Discussion

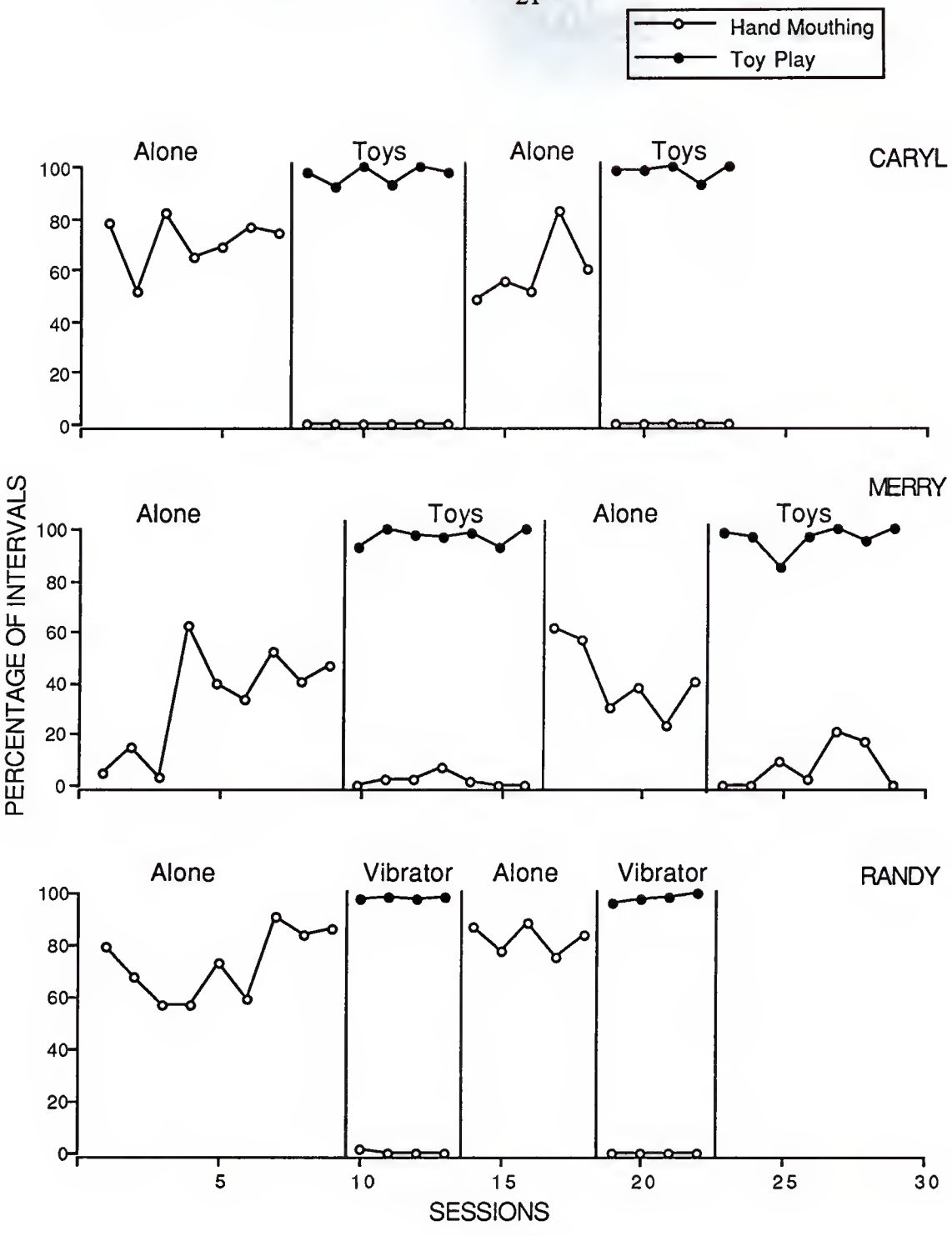
Figure 1 shows the percentage of intervals containing hand mouthing and toy playing for all three subjects across conditions. Caryl's data are shown in the top panel of Figure 1. During the alone condition, Caryl engaged in high levels of hand mouthing. When toys were provided, however, high levels of toy play were observed, while hand mouthing decreased to 0% for all six sessions. When the alone condition was reinstated, hand mouthing returning to its previous high level. When toys were reintroduced, high levels of toy play were observed, while hand mouthing again decreased to 0%.

Results for Merry are shown in the middle panel of Figure 1. During the alone condition, Merry's hand mouthing was variable. When toys were introduced, hand mouthing was virtually eliminated and was replaced with high levels of toy play. A return to Baseline showed variable amounts of hand mouthing. When toys were reintroduced, high levels of toy play were observed, while hand mouthing decreased.

Results for Randy are shown in the bottom panel of Figure 1. He engaged in a considerable amount of arm rubbing during the initial alone condition. When the vibrator was introduced, however, high levels of to play were observed, while arm rubbing was observed only once during the four sessions. A return to the alone condition showed arm rubbing again at high levels. When the vibrator was reintroduced, high levels of toy play were again observed, while no occurrences of arm rubbing were observed during any of the four sessions.

Thus, results obtained for each subject indicated that when toys were continuously available, hand mouthing/arm rubbing were almost totally eliminated. These findings

Figure 1. Percentage of intervals of hand mouthing and toy playing during alone and toy play conditions for Caryl, Merry, and Randy.


Hand Mouthing
Toy Play
Alone
Toys
Alone
Toys
CARYL
MERRY
RANDY
Vibrator
PERCENTAGE OF INTERVALS
SESSIONS
0
20
40
60
80
100
5
10
15
20
25
30

suggest that the stimulation obtained from toy play was preferred over that obtained from the hand mouthing/arm rubbing, and replicated the results of previous studies showing substitutable relationships between toy play and self-stimulatory behavior (Berkson & Mason, 1965; Davenport & Berkson, 1963; Favell et al., 1982; Goh et al., in press). Results of basic research examining reinforcer substitutability, however, suggest that substitution effects are context dependent: Parameters such as rate, magnitude, or delay to reinforcement have been shown to totally eliminate preferences. Therefore, it seemed reasonable to explore further the parameters affecting the substitutable relationship demonstrated in Experiment One.

Experiment Two

Cowdery et al. (1990) suggested that although providing alternative play activities may be effective in reducing or eliminating self-injury or stereotypic behavior, it may not be viable or practical for several reasons. They stated that these activities are often unavailable, may require one-to-one supervision to ensure continued play, and can lose their reinforcing functions due to satiation. In addition, it would be difficult to train other skills if toy play had to be continuously available. Cowdery et al. evaluated the effects of DRO in reducing the stereotypic scratching of a young boy, and suggested that, if effective, DRO could be used during times when alternative activities were not available. Using pennies that could be exchanged for preferred play items as reinforcers, results showed that the DRO successfully eliminated the boy's self-scratching.

Most research examining the efficacy of DRO/DRA procedures to reduce automatically-reinforced aberrant behavior, such as in the Cowdery et al. (1990) example, have used arbitrary reinforcers without eliminating the reinforcement directly produced by the aberrant behavior (i.e., extinction) (see Vollmer & Iwata, 1992, for a recent review).

Thus, the efficacy of differential reinforcement may depend on how well the stimulus used as the arbitrary reinforcer competed with the maintaining reinforcer. One method to increase the likelihood that a reinforcer will compete with that obtained from the aberrant behavior would be to conduct a stimulus preference assessment. For example, Steege et al. (1990) successfully treated subjects displaying stereotypy and SIB with DRO procedures by first conducting a stimulus preference assessment and then using the most preferred stimuli as reinforcers in a DRO contingency to reduce SIB. The use of DRO without extinction as a treatment intervention exemplifies one case in which interactions between concurrently available reinforcers may require careful consideration. In the current study, Experiment One showed that continuous access to toys virtually eliminated hand mouthing for two subjects and arm rubbing for another subject; the reinforcement obtained from the toys was preferred over reinforcement obtained from hand mouthing or arm rubbing. Thus, the results suggest that these items might be effective in a DRO contingency to reduce hand mouthing/arm rubbing. Thus, the purpose of Experiment Two was to examine the efficacy of DRO using the preferred toys as reinforcers.

Method

A parametric analysis of varying DRO schedules was conducted for all three subjects. Each DRO schedule had two manipulable components: the DRO interval length and the duration of access to the reinforcer. These two parameters were manipulated in various combinations in an attempt to find an effective DRO schedule for reducing hand mouthing/arm rubbing. The conditions are described below.

Alone. This condition was identical to the previous alone condition in Experiment One and served as an initial Baseline.

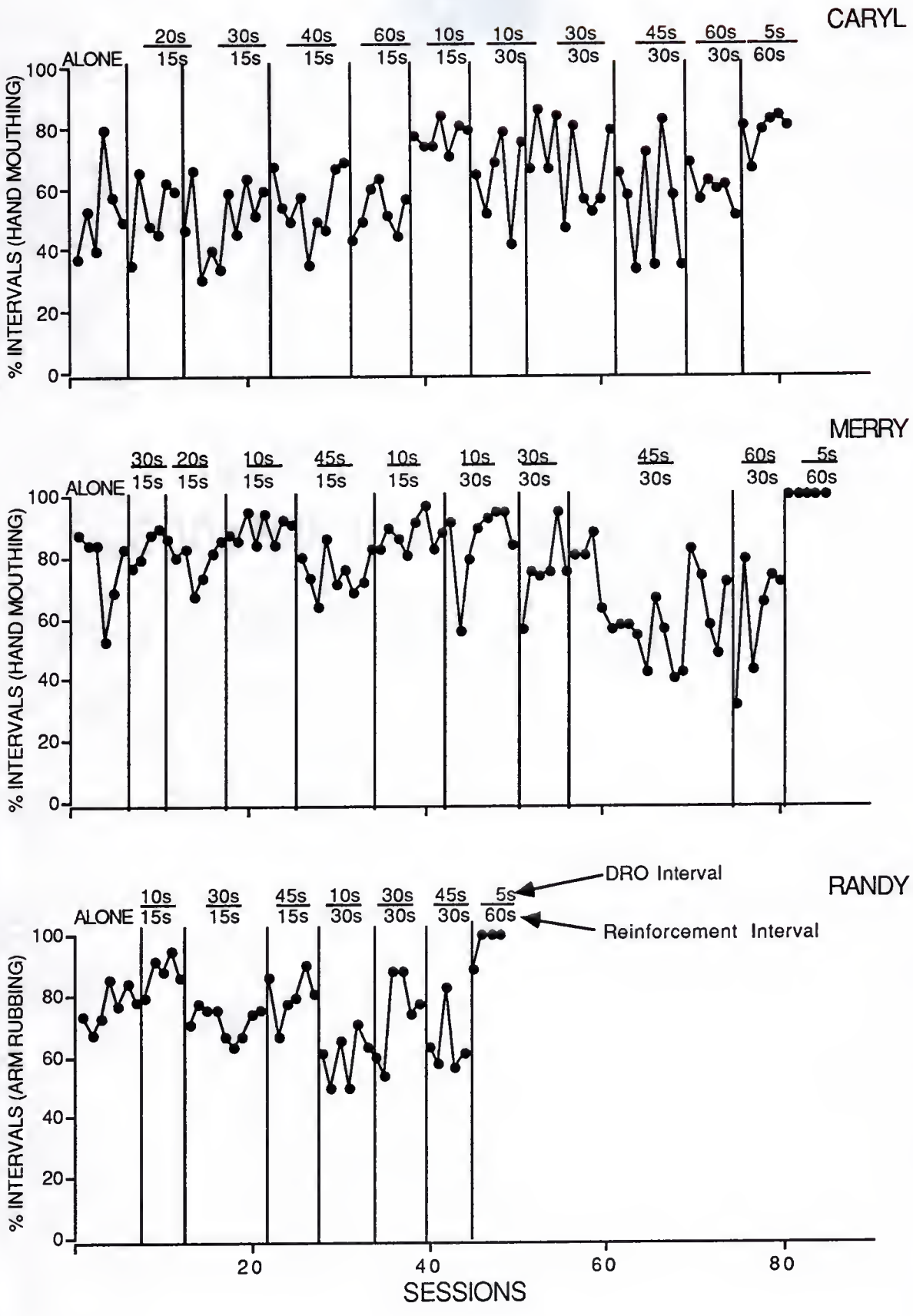
DRO. The therapist delivered the preferred toy item according a resetting DRO schedule. If the subject did not engage in hand mouthing/arm rubbing during an interval,

the toy was delivered at the end of the interval for a prespecified amount of time. If the subject engaged in hand mouthing/arm rubbing at any time during an interval, the DRO timer was reset. The DRO interval length and toy access time for the DRO schedules varied across conditions. The therapist kept track of session time, DRO interval time, and toy access time with two stop watches. Session time was stopped during toy access time to keep the total amount of time the subject was without the toy constant. This control procedure was included to insure that changes in responding from baseline to treatment were not merely a function of increased access to the toys. Therefore, although total session time varied according to how many times a subject met the DRO reinforcement criterion, the amount of time in session (without the toy) remained constant at 10 min. When the subject did not engage in hand mouthing/arm rubbing for the predefined DRO interval, the therapist stopped the session time watch, handed the subject the toy and started the toy access stopwatch. At the end of the access interval, the toy was removed, and the next DRO interval began. For each subject, toy access time was 15 s, 30 s, and 60 s, according to the predetermined schedule. The initial DRO interval was slightly shorter than the mean interresponse time obtained during the Alone condition, and subsequent DRO interval lengths were arbitrarily varied. Observers recorded the occurrence of hand mouthing/arm rubbing and toy play, and the number of times the toy was given to the subject, as described previously.

Results and Discussion

Figure 2 shows the percentage of intervals containing hand mouthing or arm rubbing across sessions and conditions for all three subjects. The top panel for Figure 2 shows the results for Caryl. During the alone condition, Caryl engaged in high and variable amounts of hand mouthing. In the next five conditions, the DRO interval length varied (20 s, 30 s, 40 s, 60 s, and 10 s), while toy access time remained constant at 15 s.

Figure 2. Percentage of intervals of hand mouthing/arm rubbing during the alone baseline and across DRO conditions for Caryl, Merry, and Randy. Numbers above each condition reflect DRO interval length (top #) and toy access time (bottom #).


CARYL
ALONE
20s 15s
30s 15s
40s 15s
60s 15s
10s 15s
10s 30s
30s 30s
45s 30s
60s 30s
5s 60s
% INTERVALS (HAND MOUTHING)
MERRY
ALONE
30s 15s
20s 15s
10s 15s
45s 15s
10s 15s
10s 30s
30s 30s
45s 30s
60s 30s
5s 60s
% INTERVALS (HAND MOUTHING)
RANDY
DRO Interval
Reinforcement Interval
ALONE
10s 15s
30s 15s
45s 15s
10s 30s
30s 30s
45s 30s
5s 60s
% INTERVALS (ARM RUBBING)
SESSIONS

No reductions in hand mouthing occurred during any of the conditions, although the number of times that Caryl met the criterion for reinforcement varied according to the DRO schedule. The mean numbers of times that Caryl met the criterion for reinforcement for each condition were: 1.8 for DRO 60 s, 3.4 for DRO 40 s, 8.8 for DRO 30 s, 15.1 for DRO 20 s, and 12 for DRO 10 s. During the next four DRO schedules (DRO 60 s, 45 s, 30 s, and 10 s), toy access time was increased to 30 s. Again, although there were no reductions in the amount of hand mouthing across conditions, the number of times that Caryl met the criterion for reinforcement varied according to DRO schedule: 0.8 for DRO 60 s, 3 for DRO 45 s, 2.9 for DRO 30 s, and 15.5 for DRO 10 s. The last attempt to reduce hand mouthing was a DRO 5 s schedule, during which 60 s access to the toys was provided. This condition appeared to increase, rather than decrease hand mouthing, and mean number of times she met criterion for reinforcement was 18.3.

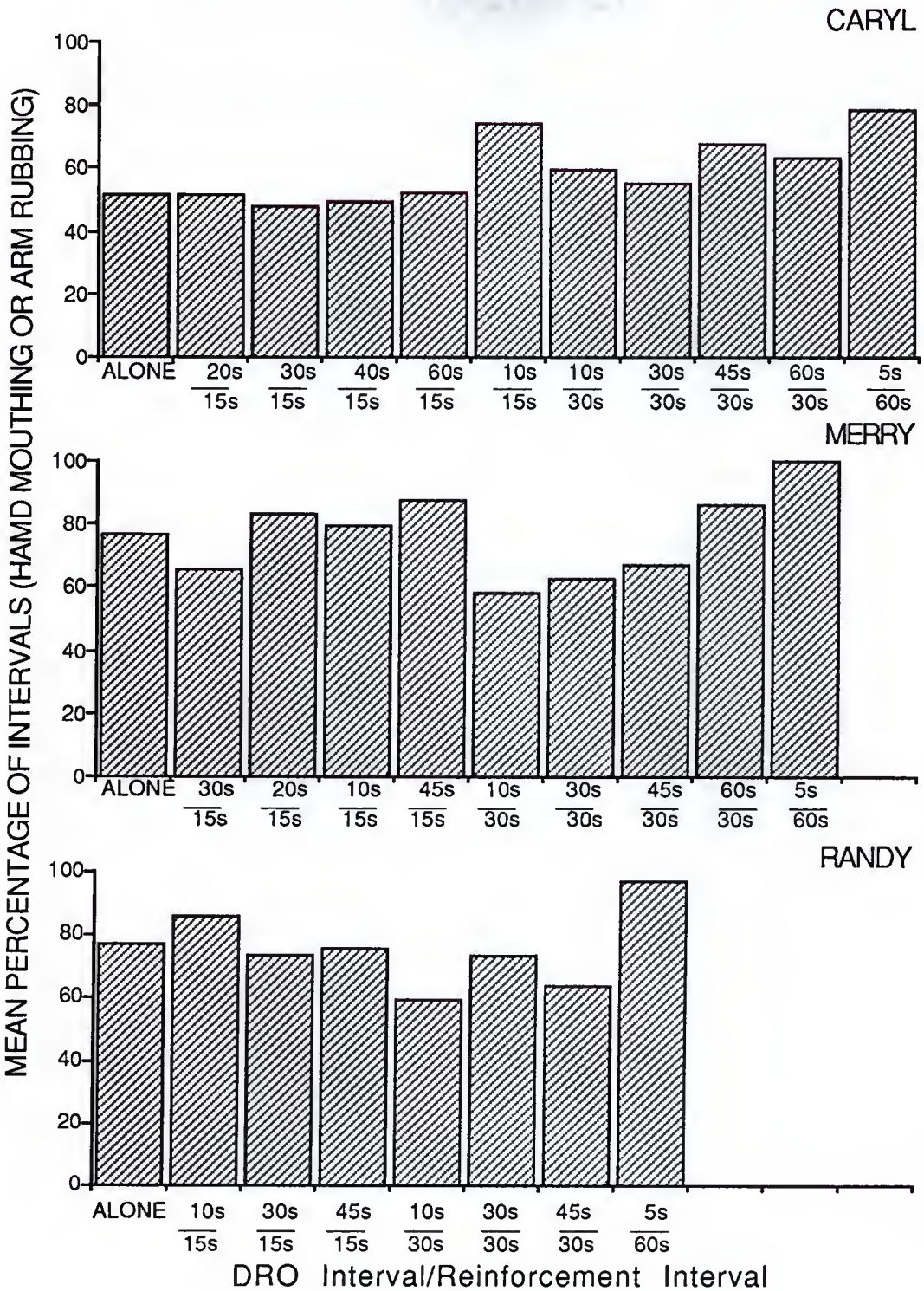
The middle panel of Figure 2 shows Merry's results. During the alone condition, Merry engaged in high and variable amounts of hand mouthing. In the next four conditions, the DRO interval length varied (45 s, 30 s, 20 s, and 10 s), while the toy access time remained at 15 s. No reductions in hand mouthing occurred during any of the conditions, although the number of times Merry met the criterion for reinforcement varied according to DRO schedule. The mean number of times Merry met the criterion for reinforcement were: 0.2 for DRO 45 s, 1.3 for DRO 30 s, 4.9 for DRO 20 s, and 11.6 for DRO 10 s. During the next four conditions (DRO 60 s, 45 s, 30 s, and 10 s), the toy access time was increased to 30 s. Again, there was no reduction in hand mouthing in any of these conditions, and number of times Merry met criterion for reinforcement varied according to DRO schedule: 0.4 for DRO 60 s, 3.1 for DRO 45 s, 2.2 for DRO 30 s, and 8.5 for DRO 10 s. The last attempt to reduce hand mouthing was a DRO 5 s schedule, during which 60 s access to the toys was provided. This condition appeared to increase,

rather than decrease hand mouthing, and mean number of times she met criterion for reinforcement was 21.8.

The bottom panel of Figure 2 shows Randy's results. During the alone condition, Randy engaged in high levels of arm rubbing. In the next three conditions, the DRO interval length varied(10 s, 30 s, and 45 s), while vibrator access time remained at 15 s. There were no reductions in arm rubbing during any of these conditions, although the number of times Randy met criterion for reinforcement varied according to the DRO schedule. The mean numbers of times Randy met criterion for reinforcement were: 15 for DRO 10 s, 2.6 for DRO 30 s, and 0 for DRO 45 s. During the next three conditions (DRO 10 s, 30 s, and 45 s), vibrator access time was increased to 30 s. Again, there was no reduction in arm rubbing in any of these conditions, and number of times met criterion for reinforcement again varied according to DRO schedule: 21.8 for DRO 10 s, 1.8 for DRO 30 s, and 1 for DRO 45 s. The last attempt to reduce arm rubbing was a DRO 5 s schedule, during which 60 s access to the vibrator was provided. This condition appeared to increase, rather than decrease arm rubbing, and mean number of times he met the DRO was 39.3.

Figure 3 shows the mean percentage of intervals containing hand mouthing or arm rubbing across conditions for all three subjects. The top graph shows the results for Caryl, the middle graph shows results for Merry, and the bottom graph shows results for Randy. For all three subjects, there were no clinically significant reductions in hand mouthing or arm rubbing from the alone condition during any of the DRO schedule manipulations. There were also no consistent parametric differences across schedules, except that all three subjects engaged in the most hand mouthing/arm rubbing during the DRO 5 s/60 s schedule. These results seem unusual because the most hand mouthing/arm rubbing for all three subjects occurred in a condition most closely resembling continuous access to the toy (DRO 5 s, with 60 s access to the toys). One plausible explanation for the increase is the

Figure 3. Mean percentage of intervals of hand mouthing/arm rubbing during alone baseline and across DRO conditions for Caryl, Merry, and Randy. Numbers below each DRO condition reflect DRO interval length (top #) and toy access time (bottom #).


CARYL
MERRY
RANDY
MEAN PERCENTAGE OF INTERVALS (HAMD MOUTHING OR ARM RUBBING)
100
80
60
40
20
0
ALONE
20s/15s
30s/15s
40s/15s
60s/15s
10s/15s
10s/30s
30s/30s
45s/30s
60s/30s
5s/60s
30s/15s
20s/15s
10s/15s
45s/15s
10s/30s
30s/30s
45s/30s
60s/30s
5s/60s
10s/15s
30s/15s
45s/15s
10s/30s
30s/30s
45s/30s
5s/60s
DRO Interval/Reinforcement Interval

nature of the measurement method combined with the very short DRO interval length. Because the DRO interval length (5 s) was shorter than the observation interval length (10 s), the subject could emit a response at the beginning of an observation interval (resulting in a scored interval), but still meet the DRO criterion within that same scored interval. In addition, short interresponse times were being reinforced (5 s) with very long reinforcement times (60 s).

Even though a clear preference for toys was shown for all three subjects when toys were continuously available during Experiment One, none of the DRO schedules showed the toys as an effective reinforcer to reduce hand mouthing/arm rubbing in Experiment Two in spite of numerous manipulations in the DRO schedule. Given the results of basic research showing changing preference under differing contexts, it seems reasonable to assume that preference for toys vs. hand mouthing/arm rubbing might also prove to be context-dependent. Basic researchers have shown that changes in reinforcer dimensions such as rate, magnitude, schedule, or delay to reinforcement, can effectively eliminate preferences (Kagel et al., 1975; Rachlin et al., 1976). In behavioral economic terms, these parameters represent "price requirements." Similarly, DRO schedules might be viewed as another sort of "price requirement." The price requirement in DRO, however, involves not responding to obtain the alternative reinforcer. Under these conditions, the subject's responding was not affected by any of the DRO manipulations. Therefore, perhaps a better way to examine changes in preference would be to alter some other parameter of "price" that involves responding to obtain the alternative reinforcer. Experiment Three, therefore, further examined parameters affecting the preference for toys over hand mouthing or arm rubbing.

Experiment Three

Most behavioral economic research examining the effects of reinforcement on behavior has defined price as the number of responses per reinforcer under fixed-ratio (FR) schedules (e.g., Hursh, Raslear, Shurtleff, Bauman, & Simmons, 1988). Some investigators, however, have suggested that a more fundamental definition of price would also include the amount of work expended per reinforcer (Hursh, 1980). Thus, unit price would be defined as a cost-benefit ratio that would specify the amount of work expended per unit of reinforcer. Hursh et al. (1988) tested this concept of unit price with rats pressing levers for food pellets in a closed economy (the entire daily ration of food was earned during the experimental procedure). Four dimensions of price were varied: (a) the response requirement for food delivery (FR schedule); (b) the number of pellets delivered per FR completion; (c) the effort required to make a response (lever force); and (d) the probability that completion of a response requirement would result in food delivery. The results confirmed that effort expended per unit of food value earned was the underlying dimension of price determining consumption of food in a closed economy.

In a more recent study examining the reinforcer and response dimensions that influence choices made by students with emotional disorders, Neef, Shade, and Miller (1994) examined how reinforcer rate, quality, delay, and response effort combined to affect time allocation across alternative math tasks on concurrent variable-interval schedules of reinforcement. Neef et al. assessed the effects of these reinforcer and response dimensions by counterbalancing the competing dimensions across six conditions, permitting examination of the effects of each dimension on time allocation. Results showed that time allocated to the different problem sets was differentially affected by the reinforcer and/or response dimensions. These studies suggest that one other parameter affecting reinforcer efficacy is response effort.

The purpose of Experiment 3 was to examine the effects of systematically altering response effort in a parametric analysis of choice between the toy items and hand mouthing/arm rubbing. Effort to obtain one reinforcer (hand mouthing or arm rubbing) would be difficult to manipulate and therefore remained constant, but effort to obtain the other reinforcer (toys) could be (and was) manipulated. This was accomplished by attaching the toys with string to a table in front of of each subject; response effort was then manipulated by varying the distance between the subjects and the toys.

Method

A reversal design with replications across subjects was used in the parametric demonstration. Following an alone baseline, response effort was systematically altered beginning with the easiest (least effortful) condition. Once preference switched from toy play to hand mouthing or arm rubbing, conditions on each side of this "switch point" were replicated. The conditions are described below.

Alone. This condition was identical to the previously described alone sessions in Experiments One and Two.

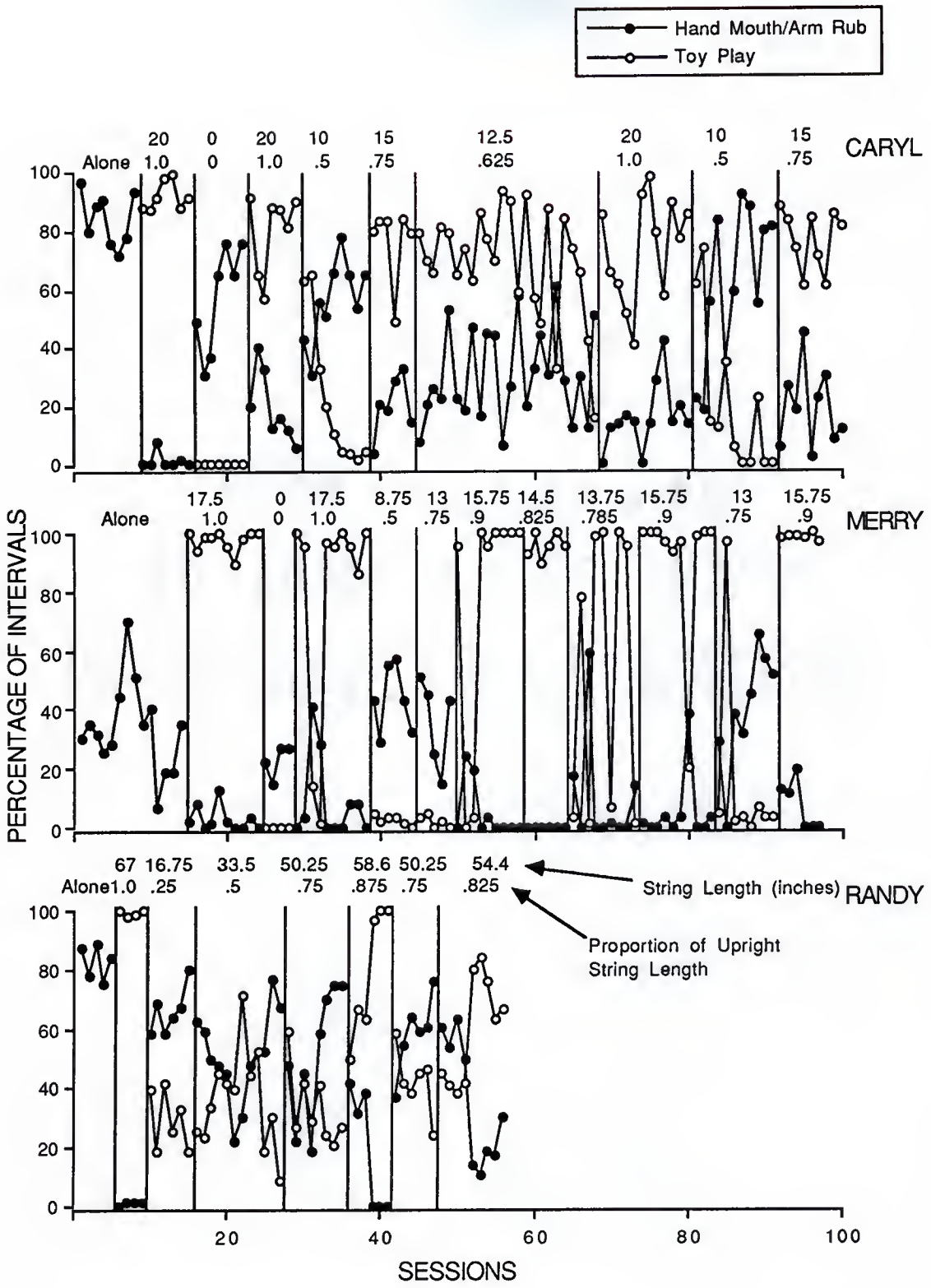
String length. All three subjects participating in this experiment (Caryl, Merry, and Randy) engaged in toy play while sitting in an upright position. Therefore, the "least effortful" condition was designed to require no change in the subjects' body position while interacting with the toys. Prior to beginning the study, the experimenter measured the distance between the edge of the table/lap tray, where the string would be attached to the table surface, and the subject's mouth while the subject was seated in an upright position. This was considered the least effortful position and was arbitrarily designated as 1.0 (proportion of string length to that obtained for the upright measurement). This distance was 20 in, 17.5 in, and 67 in, for Caryl, Merry, and Randy, respectively. Thus, the most effortful condition for all three subjects was one in which the toy was tied at its anchoring

point on the table/lap tray (0 in for all subjects, corresponding to 0 proportion of upright position). The proportion of the upright string length was then varied for each subject in an attempt to determine a switch point (e.g., the distance at which preference for the toy was eliminated), and conditions on each side of the switch were replicated. For example, the order of conditions for Caryl was 20 in (1.0), 0 in (0), 10 in (0.5), 15 in (0.75), 12.5 in (0.62, switch point), 20 in (1.0), 10 in (0.5), and 15 in (0.75).

Results and Discussion

Figure 4 shows the percentage of intervals containing hand mouthing or arm rubbing and toy play across conditions for all three subjects. The top panel shows the results for Caryl. During the alone condition, Caryl engaged in high levels of hand mouthing. The next condition was the "least effortful" condition (20 in or 1.0). During this condition, Caryl's hand mouthing was virtually eliminated, and she engaged in high levels of toy play. The next condition was most effortful (0 in or 0). During this condition, hand mouthing increased (M=56.9%) and toy play was completely absent for all seven sessions. When the 20 in (1.0) condition was reinstated, hand mouthing was initially higher than in the previous 20 in (1.0) condition, but decreased across sessions, while toy play again increased. In the next condition, 10 in (0.5), string length was reduced to one-half its original length. During the first two sessions of this condition, toy play was higher than hand mouthing, but then switched, with a steady increase in hand mouthing and a steady decrease in toy play. The next condition was 15 in (0.75 of string length). This condition was selected because it was halfway between 20 in (1.0) condition in which toy play was preferred and 10 in (0.5) condition in which hand mouthing was preferred. During this condition, hand mouthing decreased and toy play increased. Because the 15 in (0.75) condition showed a preference for toy play, and the 10 in (0.5) condition showed a preference for hand mouthing, the next condition was midway between these two conditions at 12.5 in (0.625 of string length). During this condition, most

Figure 4. Percentage of intervals of hand mouthing/arm rubbing and toy playing during the alone baseline and across string length conditions for Caryl, Merry, and Randy. Numbers above each condition reflect length of the string attached to toy (top #) and proportion of string length while the subject was seated in an upright position (bottom #).


Hand Mouth/Arm Rub
Toy Play
CARYL
Alone 1.0
20 0 20 10 15 12.5 20 10 15
0 1.0 .5 .75 .625 1.0 .5 .75
MERRY
Alone 1.0
17.5 0 17.5 8.75 13 15.75 14.5 13.75 15.75 13 15.75
0 1.0 .5 .75 .9 .825 .785 .9 .75 .9
RANDY
Alone 1.0
67 16.75 33.5 50.25 58.6 50.25 54.4
.25 .5 .75 .875 .75 .825
String Length (inches)
Proportion of Upright
String Length
PERCENTAGE OF INTERVALS
0
20
40
60
80
100
SESSIONS

sessions showed hand mouthing lower than toy play, but both responses showed considerable variability and some crossover. A return to the 20 in (1.0) condition showed decreased hand mouthing, and high and variable amounts of toy play. A reintroduction of the 10 in (0.5) condition showed toy play initially higher (as in the first 10 in condition), but hand mouthing increased to high levels and toy play decreased to low levels. The final condition replicated the 15 in (0.75) condition and showed hand mouthing low, and toy play high.

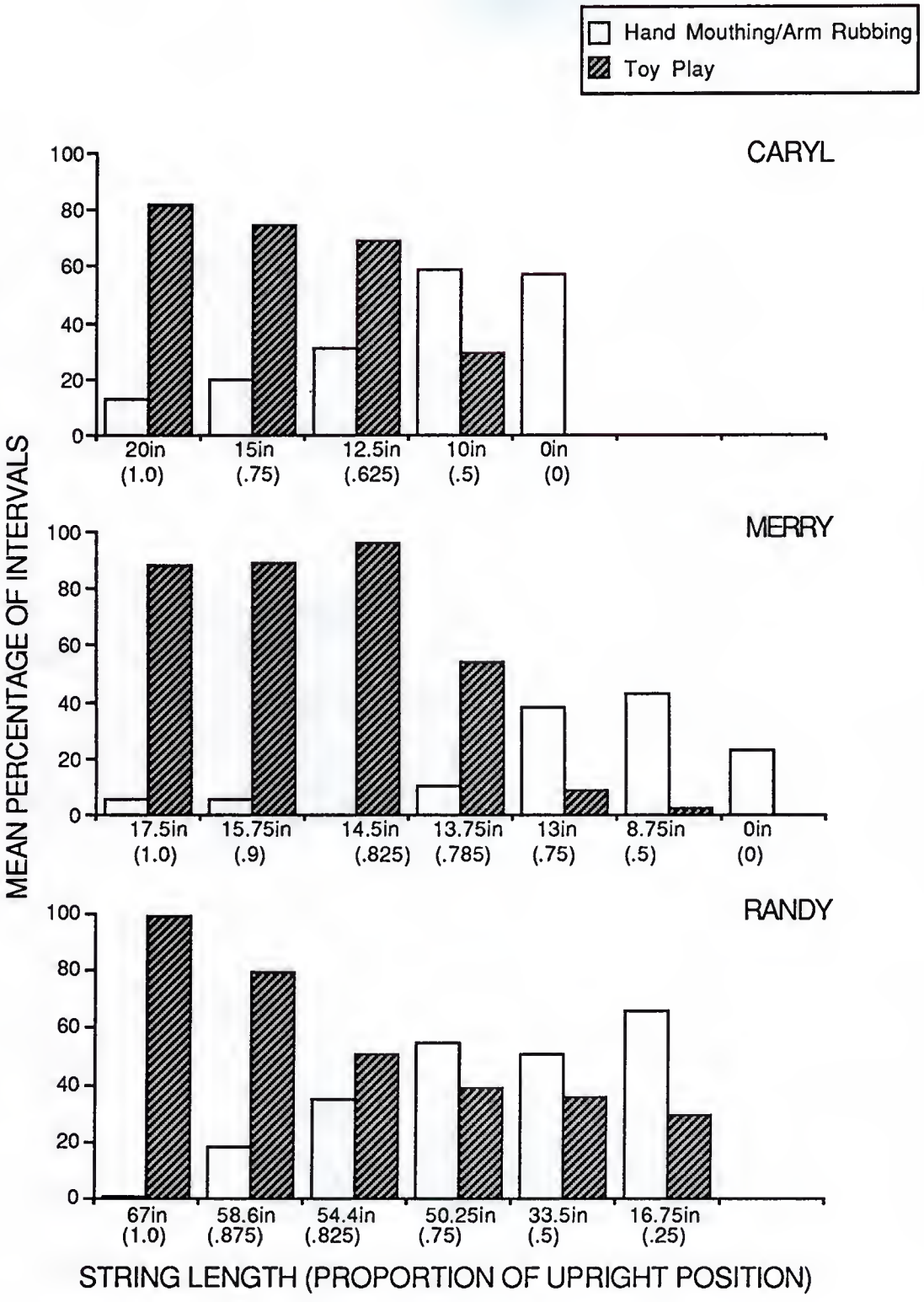
The middle panel of Figure 4 shows the results for Merry. During the alone condition, Merry engaged in variable amounts of hand mouthing. During the next condition, 17.5 in (1.0), Merry's hand mouthing decreased, and toy play was high. In the 0 in (0) condition that followed, Merry's hand mouthing increased and toy play was not observed in any of the sessions. When the 17.5 in (1.0) condition was reinstated, hand mouthing decreased, while toy play increased to high levels for all but two sessions. In the next condition, 8.75 in (0.5), string length was half of its original length. During all sessions in this condition, hand mouthing was higher than toy play . The next condition, 13 in (0.75), was halfway between the 17.5 in (1.0) and 8.75 in (0.5) conditions. During this condition, hand mouthing remained high, and toy play remained low. Because the 8.75 in (0.5) and 13 in (0.75) conditions still showed hand mouthing higher than toy play, the next condition, 15.75 in (0.9), was selected midway between the 17.5 in (1.0) and 13 in (0.75) conditions. During this condition, seven out of nine sessions showed hand mouthing completely suppressed, and toy play was high. Because 15.75 in (0.9) condition showed preference for the toy, the next condition, 14.5 in (0.825), was selected midway between the 13 in (0.75) and 15.75 in (0.9) conditions. During this condition, a complete suppression of hand mouthing occurred in all six sessions and toy play was high. Therefore, the next condition was 13.75 in (0.785), midway between the 13 in (0.75) and 14.5 in (0.825). During this condition, hand mouthing was suppressed in six out of nine

sessions, but higher in the remaining three sessions. Toy play showed an inverse pattern, with six of the nine sessions showing high levels of toy play and the remaining three sessions with low levels of toy play. A return to the 15.75 in (0.9) condition showed hand mouthing at low levels, except in one session, and toy play high, except for that same session. A reintroduction of the 13 in (0.75) condition showed hand mouthing again higher in all but one session, and toy play low in all but that same one session. The final condition replicated the 15.75 in (0.9) condition with hand mouthing low, and toy playing high.

The bottom panel of Figure 4 shows the results for Randy. During the initial alone condition, Randy engaged in high levels of arm rubbing. The 67 in (1.0) condition that followed showed an almost complete suppression of arm rubbing, and high levels of toy play. The next condition, 16.75 in (0.25), showed arm rubbing at high levels, and toy play at lower levels. Because preference in the 16.75 in (0.25) condition was for arm rubbing, the next condition was 33.5 in (0.5). During this condition, switching of preferences occurred across sessions, with arm rubbing variable but higher in most sessions than toy playing. The next condition was 50.25 in (0.75). Although the first few sessions showed no clear preference for either response, subsequent sessions showed an increase in arm rubbing, and a decrease in toy play. The next condition, 58.6 in (0.875), showed a clear preference for toy play over arm rubbing. The 50.25 in (0.75) condition was then replicated, and preference again switched (arm rubbing increased and toy play decreased). The final condition, 54.4 in (0.825), showed decreased arm rubbing after the first four sessions, and increased toy play.

Figure 5 shows the mean percentage of intervals containing hand mouthing/arm rubbing and toy play for all subjects during each string length manipulation. The top panel shows the results for Caryl. At 20 in (1.0), a clear preference for toy play over hand mouthing is shown. As string length was shortened, however, mean percentages of hand

Figure 5. Mean percentage of intervals of hand mouthing/arm rubbing and toy playing during each string length condition for Caryl, Merry, and Randy. Numbers at the bottom of each graph reflect length of the string attached to toy (top #) and proportion of string length while the subject was seated in an upright position (bottom #).


Hand Mouthing/Arm Rubbing
Toy Play
CARYL
MERRY
RANDY
MEAN PERCENTAGE OF INTERVALS
100
80
60
40
20
0
20in (1.0)
15in (.75)
12.5in (.625)
10in (.5)
0in (0)
17.5in (1.0)
15.75in (.9)
14.5in (.825)
13.75in (.785)
13in (.75)
8.75in (.5)
0in (0)
67in (1.0)
58.6in (.875)
54.4in (.825)
50.25in (.75)
33.5in (.5)
16.75in (.25)
STRING LENGTH (PROPORTION OF UPRIGHT POSITION)

mouthing increased and mean percentages of intervals toy play steadily decreased until hand mouthing became the preferred response at 10 in (0.5 of the string length). The data showed a clear and orderly inverse relationship between hand mouthing and toy play. The middle panel shows results for Merry. At string lengths of 17.5 in (1.0), 15.75 in (0.9), and 14.5 in (0.825), high mean percentage of intervals for toy play, and very low mean percentages for hand mouthing were shown. At 13.75 in (0.785 of string length), toy play decreased noticeably, and hand mouthing increased somewhat. At 13.5 in (0.75), preference for toy play was eliminated. Randy's results are shown in the bottom panel of Figure 5. His data show a decreasing trend for toy play and an increasing trend for arm rubbing as string length decreased, with preference for toy play eliminated at 50.25 in (0.75 of the string length).

These results show that altering response effort, as measured by distance of an object to an individual in an upright position, reduced preference for toys over hand mouthing or arm rubbing, and further demonstrate the contextual nature of reinforcer efficacy. Although clear preference for toys was observed in Experiment One, those preferences were reduced in Experiment Three merely by increasing the effort to obtain the preferred reinforcer, while no contingency was placed on hand mouthing. Experiment Two showed that no DRO schedule was effective in reducing hand mouthing/arm rubbing, which also suggests that preference was altered. Thus, these three experiments provide evidence that stimulus preference assessments may need to take variables such as reinforcement schedule and response effort into account when attempting to predict stimulus reinforcement efficacy.

Substitutable reinforcers represent one end of the continuum of possible interactions among reinforcers. Substitutable reinforcers serve similar functions, with one reinforcer replacing another. At the other end of the continuum are complementary reinforcers. These stimuli are not functionally similar and are considered complements because, by

definition, they are consumed jointly. Thus, an increase in consumption of one reinforcer would result in an increase in consumption of its complement. The implication for applied behavior analysts is that complementary reinforcer interactions may occur between concurrently available reinforcers that affect treatment efficacy. Study Two examined complementary relationships between reinforcers and the effect of these interactions on the assessment and treatment of hand mouthing.

STUDY TWO

Many applied studies have examined the effectiveness of providing competing or substitutable reinforcers as interventions to reduce inappropriate behavior. Much less applied research, however, has assessed interactions among complementary reinforcers. Green and Freed (1994) discussed the implications of reinforcer substitutability for treatment of inappropriate behavior in applied settings. According to the matching law, there are two obvious reinforcement-based strategies for eliminating inappropriate behavior. First, one could increase the rate of noncontingent reinforcement (NCR). In Study One, for example, noncontingent access to toys almost completely eliminated the stereotypic self-injury for all three subjects. A second strategy would be to increase the rate of reinforcement for a concurrently available response option, as exemplified in studies on differential reinforcement for alternative behavior (DRA) contingencies (Favell et al., 1982; Lockwood & Bourland 1982; Mulick et al.,1978). Results of these DRA studies show that when alternative stimuli do not entirely substitute for the aberrant behavior, additional reinforcement for the alternative may be an effective treatment. These two treatment strategies, however, may be effective only to the degree that the reinforcers are substitutable. When reinforcers are complementary, reinforcement for an alternative response may result in an increase in the behavior targeted for reduction. Therefore, an understanding of complementary relationships and the parameters affecting those interactions may be necessary when selecting potential reinforcers for use in behavior acquisition or reduction procedures.

Few studies have examined complementary interactions between reinforcing environmental stimuli and automatically-reinforced behavior. One possible example is

found in a study examining the effects of altering the physical environment on self-stimulatory behavior (Duker & Rasing, 1989). The study showed that redesigning the classroom environment by covering the walls, shelves, and replacing colorful curtains with unicolored ones resulted in three developmentally disabled males displaying much less self-stimulatory behavior and more on-task behavior during training sessions held in the room. Thus, the visual stimulation available in the less barren classroom could have been complementary to self-stimulation, with increasing amount of visual stimuli in the environment resulting in increased self-stimulation. By decreasing the visual stimulation, the complementary self-stimulation was also decreased. Thus, some self-stimulatory behavior may be evoked or potentiated by various environmental stimuli; if so, these stimuli may have adverse effects on behavior when used as reinforcers.

Food is a commonly used reinforcer in the treatment of aberrant behavior and in the acquisition of adaptive behavior. For example, in a 20-year review of reinforcement-based behavior reduction procedures, O'Brien and Repp (1990) reported that 60% of the DRO studies and 20% of the DRI studies used food as the programmed consequence. In the current study, a complementary relationship between hand mouthing and eating existed. That is, for two of the subjects previously described, Chuck and Matt, food was found during probe sessions to increase the occurrence of hand mouthing. For Chuck, Kit Kat candy bars had been found to be highly preferred in a stimulus preference assessment and to evoke the most hand mouthing during probe sessions. For Matt, pudding evoked the most hand mouthing during probe sessions and was therefore selected as the reinforcer. The purpose of Study Two was to explore the relationship between consuming these food items and hand mouthing. Three experiments were conducted: (a) a basic demonstration of the relationship between food and hand mouthing, (b) a parametric analyses of the effects of amount of food on hand mouthing, and (c) an examination of the effectiveness of food as a reinforcer in acquisition and DRO procedures.

Experiment One

Method

In Experiment One, the relationship between eating and hand mouthing, when both reinforcers were concurrently available, was examined. The conditions were presented to each subject in a reversal design (ABAB or BABA) and are described below.

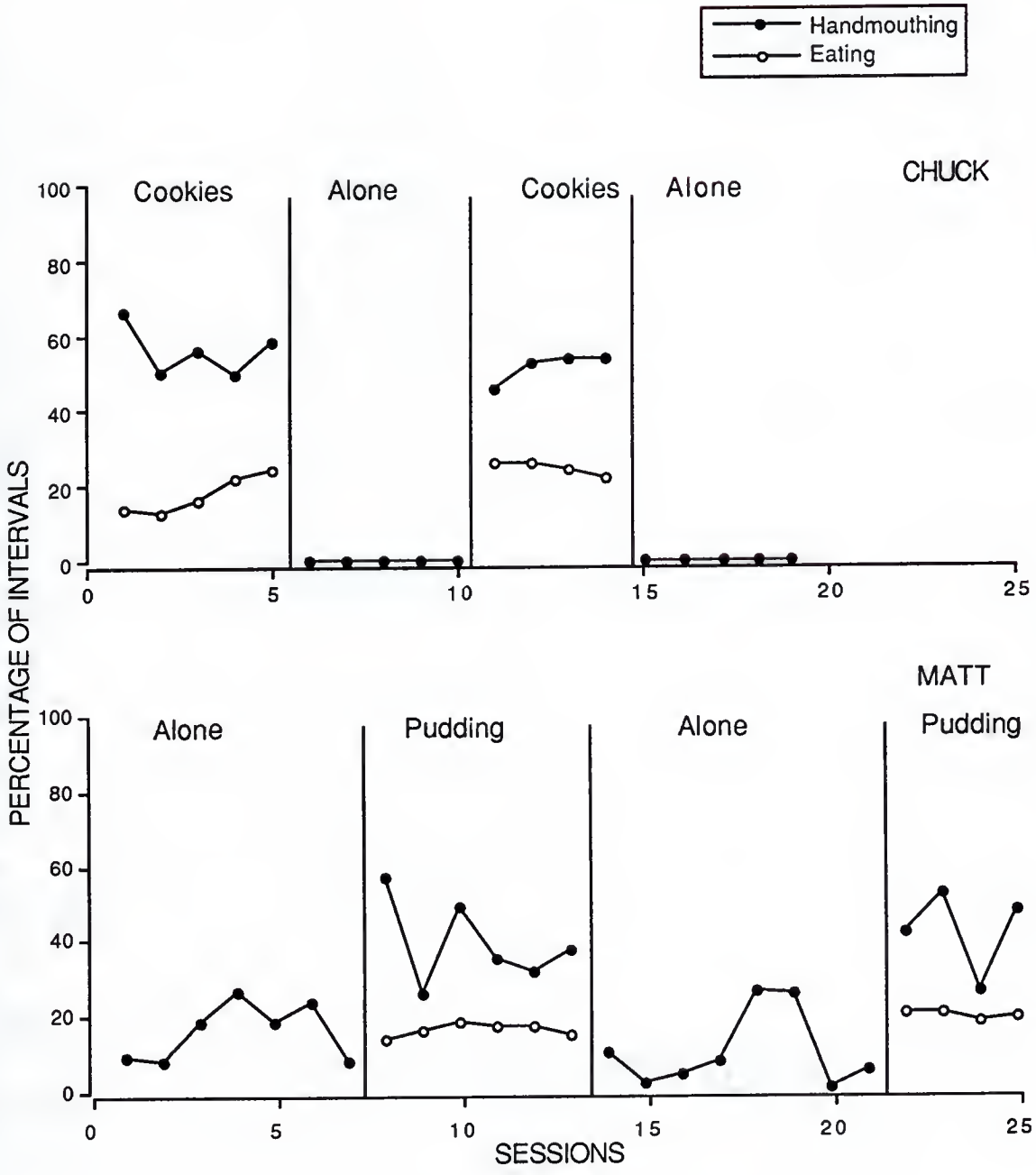
Alone. During the alone sessions, neither food nor social interaction was available. This condition was identical to the alone sessions for Study One.

Food available. During this condition, food was presented to the subjects in the following manner. For Chuck, Kit Kat candy bars were evenly divided into four parts, with each piece counted as one cookie. At the beginning of each session, Chuck was seated at a table, and a plate with 6 pieces of the Kit Kat was placed in front of him. After placing the cookies in front of Chuck, the therapist left the room and session time began. For Matt, the therapist measured 100 milliliters of pudding into a cup prior to each session. Because Matt could not feed himself, Matt's sessions began with the therapist feeding him at a slow, steady pace, and session time began when feeding started. When the pudding was gone, Matt's therapist left the room. Observers recorded hand mouthing and eating for both subjects.

Results and Discussion

The results for Experiment One are shown in Figure 6. The top panel of Figure 6 shows the results for Chuck. In the first condition, when cookies were available, Chuck engaged in high levels of hand mouthing, and moderate amounts of eating. In the subsequent alone condition, Chuck did not engage in hand mouthing for any of the five sessions. When cookies were reintroduced, Chuck again engaged in high levels of hand

Figure 6. Percentage of intervals of hand mouthing and eating during food and alone conditions for Chuck and Matt.


Handmouthing
Eating
CHUCK
Cookies
Alone
Cookies
Alone
MATT
Alone
Pudding
Alone
Pudding
PERCENTAGE OF INTERVALS
SESSIONS
0
20
40
60
80
100
0
5
10
15
20
25

mouthing, and moderate amounts of eating. The alone condition was then reinstated, and no hand mouthing was observed in any of the five sessions.

The bottom panel of Figure 6 shows the results for Matt. In the initial alone condition, Matt engaged in low to moderate amounts of hand mouthing. When pudding was available in the next condition, however, hand mouthing increased (the amount of eating was low and stable). The alone condition was then reinstated, with hand mouthing relatively low. When the pudding condition was reinstated, hand mouthing again increased (time spent eating was again low and stable).

These results showed that, for both subjects, hand mouthing increased when food was consumed. When food was not available, Chuck did not engage in hand mouthing at all, and Matt's hand mouthing was reduced. Thus, consumption of food increased the reinforcing efficacy of hand mouthing and may have served as an establishing operation (Michael, 1982) for hand mouthing. Basic experimental studies examining complementary relationships have shown that varying the amount of one reinforcer can affect the rate of consumption of an alternative reinforcer. For example, Allison and Mack (1978) showed (with rats lever pressing for food pellets) that eating and drinking were substitutable when eating was suppressed, but complementary when drinking was suppressed. Thus, amount of food consumed may be an important variable to consider when using food as a reinforcer. Therefore, the purpose of Experiment Two was to determine if changes in the amount of food available would alter the time spent hand mouthing.

Experiment Two

Method

A parametric analysis of varying amounts of food was conducted for both subjects. For Chuck, several reversals occurred in the order of 12-6-12-3-12-1 cookies. For Matt,

milliliters of pudding were varied in the order of 100-50-200-25-12.5-6.25-3. Sessions were conducted just as they had been in Experiment One, and observers scored the occurrence of eating and hand mouthing as previously described.

Results and Discussion

The results of Experiment Two are shown in Figures 7 and 8. Figure 7 shows the percentage of intervals containing hand mouthing and eating across sessions for both subjects. The top panel of Figure 7 shows the results for Chuck. During the initial 12 cookies condition, Chuck engaged variable amounts of hand mouthing (M=25.8%) and eating (M= 12.5%). Hand mouthing continued to be variable across the remaining conditions, with mean percentages of intervals at 21.3% (6 cookies), 46.5% (12 cookies), 29.8% (3 cookies), 50.9% (12 cookies), and 30.1% (1 cookie). Although the amount of hand mouthing did not change systematically with the number of cookies, predictably the amount of eating did, with mean percentages of intervals eating increasing as the number of cookies increased.

The bottom panel of Figure 7 shows the results for Matt. During the initial pudding condition (100 ml) Matt showed variable amounts of hand mouthing (M= 42.2%) and stable amounts of eating (M=20%). Similar amounts of hand mouthing were shown across the remaining conditions with mean percentages of intervals of hand mouthing at 37.6% (50 ml), 30.2% (200 ml), 48.5% (25 ml), 28.5% (12.5 ml), 50.8% (6.25 ml), and 45.8% (3 ml). Time spent eating predictably increased as amount of pudding increased.

Figure 8 shows the mean percentages of intervals spent hand mouthing or eating across conditions. The top panel shows results for Chuck, and the bottom panel shows results for Matt. Both subjects showed increasing mean percentages of intervals eating as the amount of food increased, but neither showed any systematic change in the mean percentages of intervals hand mouthing as a function of the amount of food consumed.

Figure 7. Percentage of intervals of hand mouthing and eating during each of the food conditions for Chuck and Matt. Numbers above each graph reflect the number of cookie pieces (Chuck) and the milliliters of pudding (Matt).

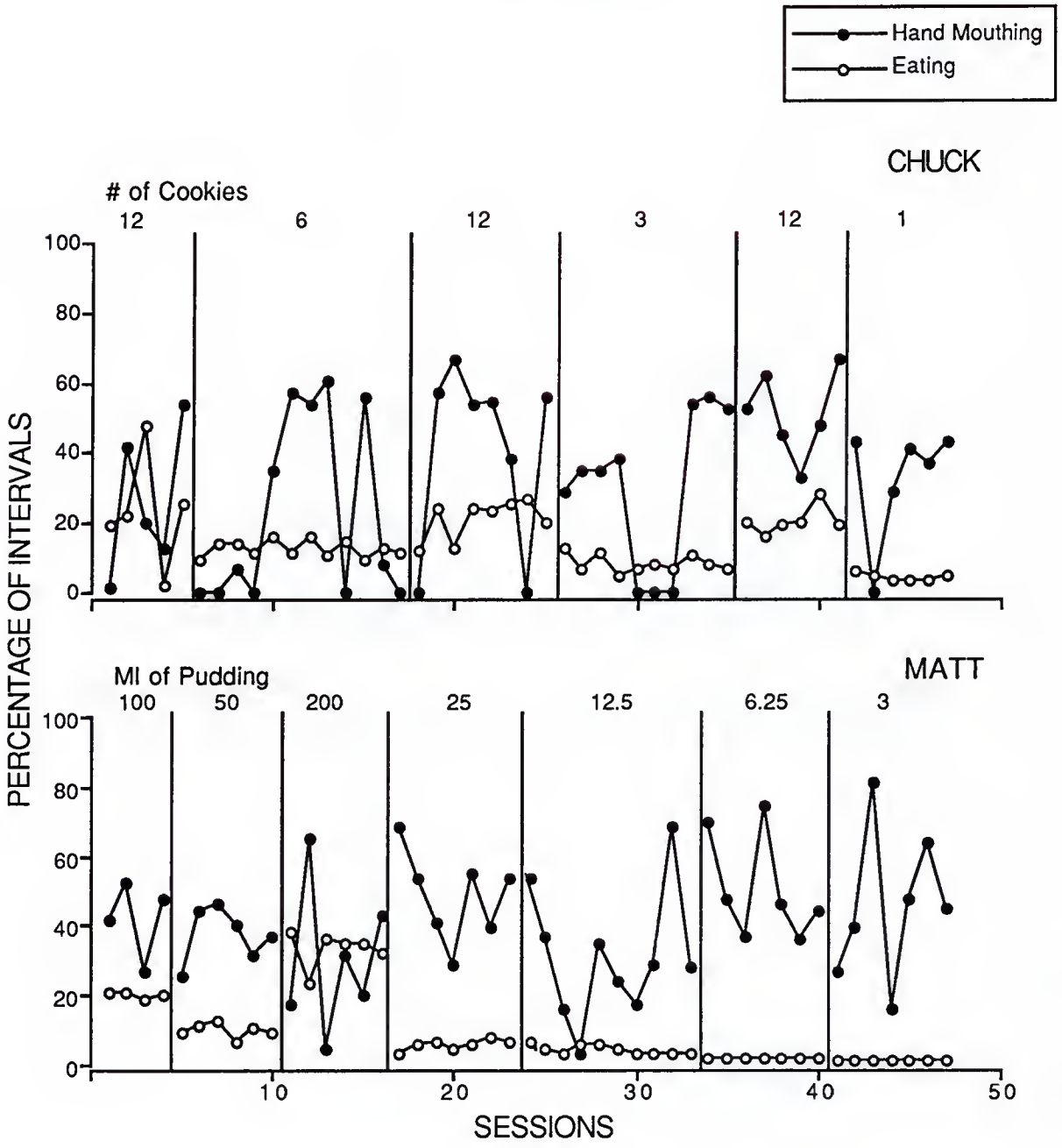
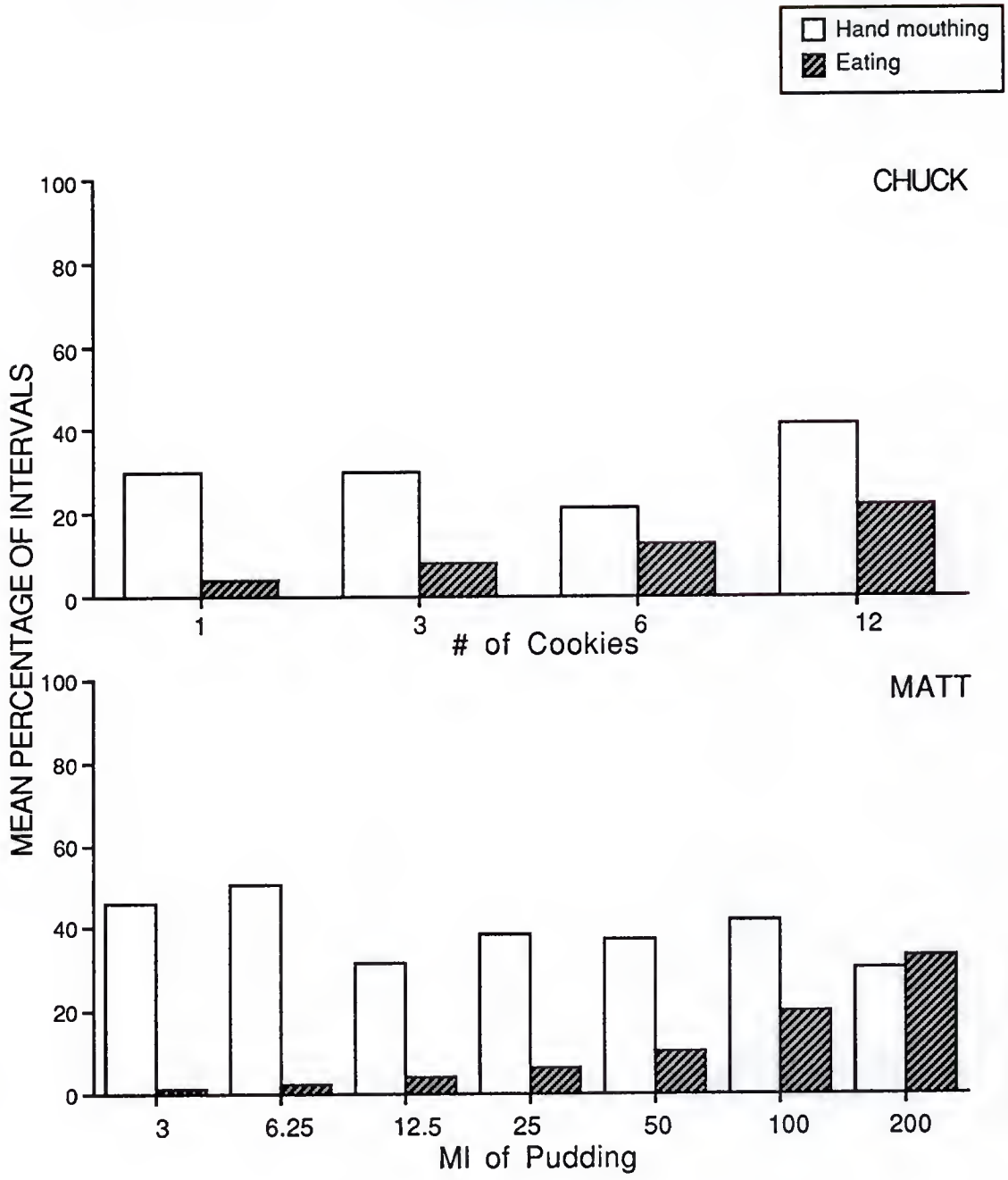

Hand Mouthing
Eating
CHUCK
# of Cookies
12
6
12
3
12
1
MATT
Ml of Pudding
100
50
200
25
12.5
6.25
3
PERCENTAGE OF INTERVALS
SESSIONS
0
20
40
60
80
100
10
20
30
40
50

Figure 8. Mean percentage of intervals of hand mouthing and eating across food conditions for Chuck and Matt. Numbers below each graph reflect the number of cookie pieces (Chuck) and milliliters of pudding (Matt).


Hand mouthing
Eating
CHUCK
MEAN PERCENTAGE OF INTERVALS
100
80
60
40
20
0
1
3
6
12
# of Cookies
MATT
100
80
60
40
20
0
3
6.25
12.5
25
50
100
200
MI of Pudding

These results suggest that the preferred food items established hand mouthing as reinforcing regardless of the amount of food consumed.

Experiment Three

Food is frequently used as a reinforcer in both behavioral acquisition programs and in procedures used to reduce inappropriate behavior. In fact, for these two subjects, stimulus preference assessments showed food to be highly preferred stimuli. The demonstration in Experiment One illustrated, however, that for these two subjects, consumption of preferred food increased the reinforcing efficacy of inappropriate behavior (hand mouthing). The second experiment suggested that food would result in increased hand mouthing across a wide range of food amounts. For Chuck, hand mouthing did not appear to be a problem until food was introduced. Thus, in the absence of food, there was no hand mouthing in need of treatment. Because, however, food seemed to be a highly preferred stimulus for Chuck, it was used as a reinforcer in some of his training programs and may have had the unintended effect of disrupting his performance. Therefore, an examination of the effects of food as reinforcement in an acquisition-type context would be of clinical interest for Chuck. Matt, however, engaged in hand mouthing in the absence of consuming food. Thus, examining the use of food in a DRO contingency to reduce hand mouthing would be of interest for Matt. The purpose of Experiment Three, therefore, was to examine the efficacy of the edible reinforcers in acquisition training during a free operant task (Chuck) and during a DRO contingency to reduce hand mouthing (Matt).

Acquisition procedures (Chuck)

All sessions were 10 min in length, and conditions were alternated in a reversal design (ABA). The response of interest was placing blocks in a bucket. Chuck was seated

in a chair facing a table, on which were located a bucket and a number of small blocks. The experimenter began the session by modeling the response (i.e., placing one block into the bucket). This modeling was repeated on an FT (fixed t ime) 1 min schedule throughout the session for a total of 10 modeling prompts. No further instructions or prompts were provided. Observers scored the number of blocks placed in the bucket by Chuck, number of modeled responses by the experimenter, and the occurrence of hand mouthing by Chuck.

Baseline. The experimenter modeled the response on the FT 1 min schedule and did not provide any further instruction, prompts, or reinforcement.

Reinforcement. This condition was identical to baseline, except that the experimenter delivered one piece of Kit Kat cookie contingent on each occurrence of placing a block in the bucket.

DRO procedure (Matt)

Alone. Baseline consisted of the alone condition previously described. Observers recorded the occurrence of hand mouthing, and the experimenter measured the interreponse times (IRTs) with a stopwatch. Mean IRT across the baseline sessions was then determined by adding all durations of IRTs and dividing by the number of IRTs.

DRO. The DRO interval was set slightly greater than the mean IRT for hand mouthing as determined from baseline observations. The experimenter fed one level spoon of pudding to Matt contingent on the absence of hand mouthing according to a resetting DRO 30 s schedule. If Matt did not engage in hand mouthing during a 30 s interval, the food was delivered at the end of the interval. If the Matt engaged in hand mouthing at any time during an interval, the DRO timer was reset. Observers recorded the occurrence of hand mouthing, eating, and the number of times the pudding was delivered.

Results and Discussion

Figure 9 shows the results for Chuck. During Baseline, he displayed one instance of hand mouthing during one session; no hand mouthing occurred in any of the remaining nine sessions observed. He did, however, put blocks in the bucket, although the number of blocks he put in the bucket was variable across sessions (M= 24.5). When cookies were delivered contingent on putting blocks in the bucket, however, the response decreased (M=10), and the amount of hand mouthing increased (M=40%). A return to baseline showed a variable increase in the number of blocks in the bucket (M=40), and no hand mouthing during any of the eight sessions.

Figure 10 shows the results for Matt. In the alone condition, Matt showed variable amounts of hand mouthing (M= 30%). When pudding was delivered contingent on the absence of hand mouthing for 30 s, a slight increase was observed in hand mouthing (M= 40.9%), and time spent eating was indicative of the number of times he met the contingency (M= 33 reinforcers per session).

These results showed that both the acquisition procedure for Chuck and the DRO procedure for Matt were ineffective when a highly preferred food was used as a reinforcer. For Chuck, the Kit Kat candy presented contingent on putting blocks in the bucket reduced rather than increased responding. Eating the cookies increased hand mouthing; hand mouthing then interrupted responding. For Matt, the pudding increased the efficacy of hand mouthing and therefore did not serve as a reinforcer for the absence of hand mouthing. These results suggest that therapists should examine the interaction between stimuli selected for use as reinforcers in therapeutic programming and the effect those stimuli may have on undesirable behavior.

Figure 9. Percentage of intervals of hand mouthing and number of blocks placed in bucket for Chuck across baseline and reinforcement conditions.

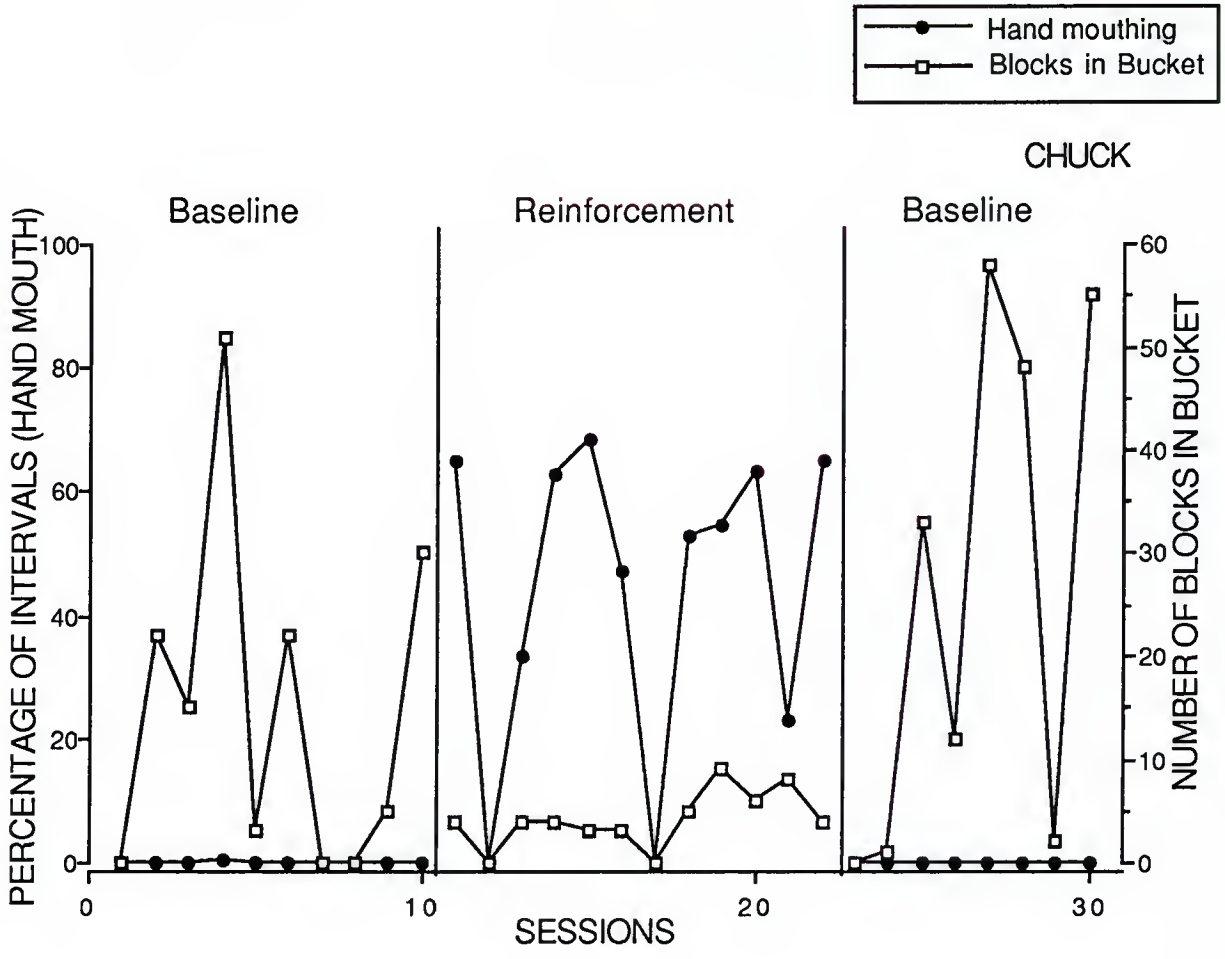
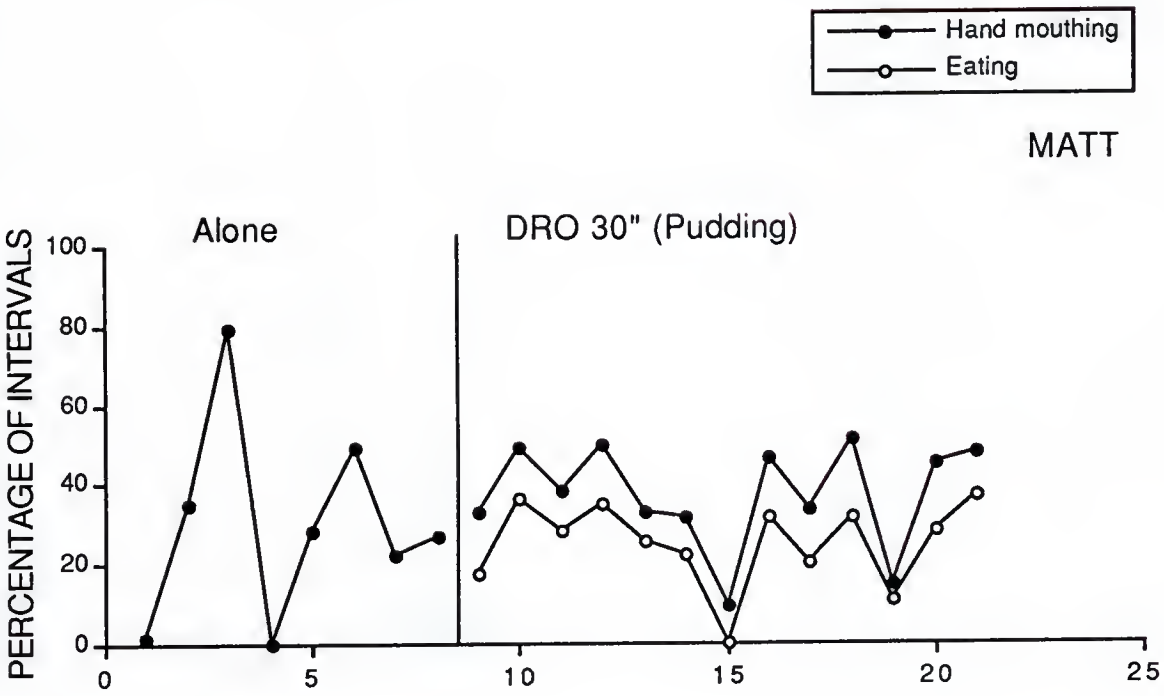

Hand mouthing
Blocks in Bucket
CHUCK
Baseline
Reinforcement
Baseline
PERCENTAGE OF INTERVALS (HAND MOUTH)
NUMBER OF BLOCKS IN BUCKET
SESSIONS
0
10
20
30
0
20
40
60
80
100
0
10
20
30
40
50
60

Figure 10. Percentage of intervals of hand mouthing and eating during the alone and DRO conditions for Matt.


Hand mouthing
Eating
MATT
Alone
DRO 30" (Pudding)
PERCENTAGE OF INTERVALS
100
80
60
40
20
0
0
5
10
15
20
25

GENERAL DISCUSSION

Results of the two studies illustrate that relationships among concurrently available reinforcers can affect behavior in numerous and complex ways. Specifically, research examining reinforcer substitutability and complementarity may provide a guide for applied behavior analysts who seek to identify potential reinforcers for both acquisition training and behavioral reduction. Understanding and identifying the parameters that alter these reinforcer relationships may be the next step in developing a technology for reinforcer assessment.

Study One examined substitutability between two automatically-reinforced behaviors-- toy play and either hand mouthing or arm rubbing. For all three subjects, time spent hand mouthing or arm rubbing and time spent toy playing were inversely related when both responses were freely available (Experiment One). These preferences for the toys, however, were shown to be context-dependent, in that preference was readily eliminated when response effort was increased (Experiment Three). In addition, even though toys were highly preferred in the free access condition (Experiment One), the toys were not effective reinforcers in DRO contingencies to reduce hand mouthing or arm rubbing (Experiment Two). These findings are consistent with results of basic research on variables affecting choice (Green & Freed, 1994).

One explanation for the results of Study One involves reinforcer access time. Hand mouthing/arm rubbing was continuously available in all conditions of all three experiments. Therefore, presentation of an alternative stimulus would have to compete with continuous access to hand mouthing. Although toys were preferred when both stimuli were continuously available, the DRO contingencies and string length contingencies showed that

when toy play was less than continuously available, it no longer competed with hand mouthing or arm rubbing.

Another possible related explanation for the results involves temporal separation between the two reinforcers. Temporal separation has been shown to reduce the degree of substitutability between otherwise identical reinforcers. Hursh and Bauman (1987), for example, compared consumption of one reinforcer as a function of its relative price when an alternative identical reinforcer was present in three conditions of temporal separation: concurrent schedules, multiple schedules, and across conditions of the same experiment. (Green and Freed (1994) suggested this was similar to comparing prices of items on the same shelf, in different stores, or over months of shopping, respectively.) Results showed that the greater the temporal separation between identical reinforcers, the less substitutable they became. The DRO conditions in Experiment Two and the shorter string length conditions of Experiment Three resulted in temporal separations between the self-stimulation produced by toy play relative to hand mouthing (which was always immediately available). In the DRO contingencies (Experiment Two), the subjects had to not engage in hand mouthing, which presumably produced similar stimulation to that produced by toy play. In the string length conditions (Experiment Three), decreased string length created a temporal separation by forcing the subjects to engage in additional behavior to play with the toys (e.g., bending over to place the toy against the face or in the mouth).

Results of Study Two also have important implications for the assessment and treatment of automatically-reinforced aberrant behavior. The results of these experiments suggest that reinforcer assessments that do not take contextual variables into account, such as relationships between concurrently available reinforcers, may result in identification of putative reinforcers that do not serve as reinforcers, and that may in fact be contraindicated. Experiment One demonstrated that some stimuli that would be indentified as preferred in a standard stimulus preference assessment (e.g., Pace et al., 1990) may increase the

reinforcing efficacy of inappropriate behavior. When food was available, both subjects' time spent hand mouthing increased over that observed when food was not consumed. Altering the amount of food, however, did not have any effect on the amount of hand mouthing. At least for these two subjects, any amount of food appeared to increase the reinforcing efficacy of hand mouthing.

Given that food is often used as a reinforcer to teach new skills or in DRO/DRA contingencies to decrease inappropriate behavior, the results of Experiment Three have important implications for applied behavior analysts. When treating automatically-reinforced behavior problems, the importance of examining the collateral effects of reinforcer consumption on the occurrence of other behavior may be particularly relevant. Data from Experiment Three (Figure 9) showed that food was ineffective as a reinforcer for Chuck's block-in-bucket responding. In fact, responding was suppressed when food was delivered contingent on performance. For Matt (Figure 10), the DRO contingency resulted in a slight increase in hand mouthing. These results are not surprising when one considers that, for both subjects, any amount of the preferred food item increased hand mouthing. Hand mouthing, therefore, had a disruptive effect on acquisition. Further research should be conducted to examine when, or if, a complementary reinforcer that establishes a problem behavior as reinforcing, can serve as a reinforcer for other behavior.

There are several limitations to these experiments worth noting. First, sequence effects may have occurred in the parametric studies. In the DRO experiment of Study One (Figure 2), for example, all three subjects were exposed to first 15 s, and then 30 s reinforcement intervals. Although the DRO intervals varied between subjects, it is not known if the sequence of conditions affected the results. Similar problems are found in Experiment Three of Study One (Figure 4). The sequence of conditions may have either facilitated or hampered performance in adjacent conditions. There is, in fact, some indication that preceding conditions affected subsequent conditions, in that initial

performance in some conditions showed a switch after the first couple of sessions. In Experiment 2 of Study Two (Figure 7) for Chuck, there was an attempt to control for sequence effects by returning to the 12 cookie condition every other condition. The order of conditions was different for both subjects, and similar results were obtained, suggesting that the sequence of conditions was not a confounding factor.

Another potential limitation is the experimental design used in Experiment Three of Study Two (Figure 10). For Matt, an AB demonstration was conducted and further manipulations were not pursued because no reinforcement effect was observed. Experiment Three of Study Two consists of two case studies; therefore, the results should be considered preliminary. Further research is needed to examine these variables under more rigorous experimental conditions.

Stimulus preference assessments have been receiving considerable attention in recent years (e.g., Fisher, Piazza, Bowman, Hagopian, & Langdon, 1994; Pace, et al., 1985) and have facilitated acquisition of adaptive behavior (e.g., Pace et al., 1985) as well as reduction in aberrant behavior (Steege et al., 1989). The results of this study, however, suggest that preference in one context may not be predictive of preference in another context. This may be particularly true when automatically produced reinforcement is involved. Further research is needed to develop a technology for reinforcer assessment that takes contextual variables into account.

The results of these experiments on substitutable and complementary reinforcers shed new light on previous research examining the efficacy of various interventions to reduce stereotyped aberrant behavior (i.e., behavior not maintained by social reinforcement). Directions for future research using concepts borrowed from behavioral economic theory are numerous. For example, one common method of treatment for automatically-reinforced stereotypic behavior has been to manipulate stimuli in the environment that appear to be correlated with a decrease in the occurrence of the aberrant behavior. For example, stereotypic behavior has been shown in some cases to occur more

frequently in barren environments (Berkson & Mason, 1965; Horner, 1980; Warren & Burns, 1970), and in other cases to occur more often when external stimulation is high (Adams, Tallon, & Stangle, 1980; Duker & Rasing, 1989). These studies suggest that stereotypic behavior may be established as reinforcing under conditions of either low or high sensory stimulation. For example, Duker and Rasing (1989) covered the walls and windows of a classroom to reduce the visual stimulation that appeared to be complementary to their subjects' stereotypic behavior. The current studies suggest that researchers and clinicians should look to relationships between reinforcers as possible establishing operations for other automatically-produced reinforcers.

When stereotypic behavior occurs most frequently in relatively barren environments, the appropriate intervention would consist of enriching the environment. This "enriched environment" approach to treatment, however, can be interpreted in terms of substitutability of reinforcers: Provide alternative sources of stimulation that substitute for the inappropriate self-stimulation. For example, Berkson and Mason (1965) found that subjects engaged in more stereotyped movements when alone than in a condition in which the experimenter handed the subjects toys and provided attention. This approach to treatment has the advantage of being relatively simple for caregivers to implement (Boe, 1977; Vollmer, 1994). When, however, alternative stimuli do not entirely substitute for the inappropriate behavior, combining access to the stimulus with other preferred stimuli may be effective. For example, Lockwood and Bourland (1982) used praise and brief physical contact contingent on sustained toy usage to further reduce SIB below a condition of toys only. The use of multiple reinforcers that substitute for aberrant behavior when one reinforcer is insufficient provides a good example of how the concept of substitutability may facilitate the development of more effective reinforcement-based interventions for automatically reinforced aberrant behavior.

Enriched environments, however, are not always effective in reducing aberrant

behavior. For example, Adams, et al. (1980), found lower levels of stereotypic behavior under quiet and "easy listening" music conditions than in a television-on condition. They also found that the addition of toys to the environment did not result in decreased self-stimulatory behavior. Thus, for some individuals, increased environmental stimulation may establish stereotypic behavior as reinforcing, and treatment would entail less stimulation. These studies also may be interpreted in terms of reinforcer substitutability. For some individuals, other sources of environmental stimulation may be complementary reinforcers to the automatically-reinforced behavior, with an increase in environmental stimulation resulting in an increase in the stereotypic behavior.

Given that extinction of automatically-reinforced behavior is often difficult or impossible to achieve, reinforcement-based treatments almost always involve concurrent schedules of reinforcement. Therefore, applied researchers should examine the plethora of basic research examining the parameters affecting preference between concurrently available reinforcers and assess those relationships in the treatment of automatically-reinforced problem behavior. In addition, identifying the parameters that affect preferences and/or alter the reinforcing efficacy of aberrant behavior may be facilitated by consideration of the relationships between concurrently available reinforcers. There is much to be learned about the assessment and treatment of nonsocially-mediated behavior problems, and the concept of reinforcer substitutability may facilitate that understanding.

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BIOGRAPHICAL SKETCH

After receiving a Bachelor of Science degree in public relations at the University of Florida in 1979, Bridget A. Shore worked for The Corner Drugstore in Gainesville as the Volunteer Coordinator. There she was first taught to use behavioral procedures in developing self-management programs for drug offenders and in teaching volunteers to answer a 24-hour telephone crisis intervention hot-line. In 1982, she began working at Sunland Center (now Tacachale) at Gainesville, an institution for persons with developmental disabilities, where over a five-year period she advanced from training specialist to human services senior supervisor. Through self-study, she learned more about behavior analysis, and subsequently took the state certification exam to become an HRS Certified Behavior Analyst in 1986. In 1987, Bridget became a member of the Behavior Program Review Committee at Sunland and began developing and monitoring behavior programs for persons with severe behavior problems. With this experience, she obtained the position of Behavior Consultant with HRS/DD and worked for the next two years providing assistance in the development of treatment programs for clients with behavior problems throughout a sixteen-county district. In 1990, she left her job to attend graduate school in applied behavior analysis at the University of Florida.

During Bridget's five years in graduate school, she has been a research assistant for Dr. Brian Iwata at the Florida Center on Self-Injury, located at Tachachale. As a research assistant, she has been involved in daily assessment and treatment sessions, data analysis, staff training, administrative activities, supervision of research projects, and dissemination of results through publication and conference presentations. Specific projects in which she has had extensive involvement include staff training, generalization of treatment outcomes, and the assessment and treatment of automatically-reinforced self-injury.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Brian A. Iwata, Chair
Professor of Psychology

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Marc N. Branch
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Timothy D. Hackenberg
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Michael J. Farrar
Associate Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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